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PLATES.

PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

NINETY-FIFTH SESSION.

I.—*The Report of the Royal Commission on Agricultural Depression.* By WILLIAM SMART, M.A., D.Phil., LL.D., Adam Smith Professor of Political Economy in the University of Glasgow.

[Read before the Society, 17th November, 1897.]

THE Final Report of the Royal Commission on Agriculture is so long and so full of interesting matter that I have had great difficulty in condensing it into such a form as will give the data for what I have to say in criticism of it. This must be my excuse for omitting the consideration of many matters which, from other points of view, are of the greatest importance.

Part I. of the Report is headed "Distribution and Effects of Agricultural Depression." The depression is universal, but unequal in intensity. It is worst in the arable eastern counties, particularly in Essex and Suffolk; and in these counties it is the strong clays and some very light soils that have suffered most. It is of a "milder character" in the pastoral counties; is "not so serious" in the arable section of Scotland; and is least in "districts suitable for dairying, market gardening, and poultry rearing, and in the neighbourhood of mines, quarries, large manufacturing centres, and towns, where there is a considerable demand for farm produce." As might be expected, "in some districts considerable areas have ceased to be cultivated," and there has been great contraction of the area of land under the plough. Major Craigie puts the loss of arable land at 2,137,000 acres, the diminution in wheat acreage alone accounting for nearly 2,000,000 of this. The capital value of land, which was estimated by Sir Robert Giffen in 1875 at thirty years' purchase, is estimated by Sir Alfred Milner in

1894 at eighteen years' purchase on the gross annual value assessed to Schedule A. of the Income Tax. This calculation would bring out a decline of nearly £1,000,000,000, or 50 per cent. in the capital value of land in the United Kingdom.*

Rents have fallen, irregularly indeed but universally, and that not in the form of temporary abatements, but of permanent reductions. In the most depressed counties the fall is, on the average, about 50 per cent., while on some very poor soils rent has disappeared altogether. In the less depressed counties it ranges from 20 to 30 per cent. In some dairying districts, and districts favoured by local circumstances, it is not more than 15 per cent. "In the eastern and south-eastern counties of Scotland, the reductions have been almost as great as in the more distressed parts of England, but in the south-western counties they have amounted to 10 and 15 per cent. In Wales, however, there have been few permanent reductions, although remissions and abatements from 10 to 20 per cent. have been more general." A calculation by Sir Robert Giffen, and accepted by the Commission, brings out that "the present rental value of agricultural land is appreciably less than it was fifty years ago, notwithstanding the continuous expenditure of capital on the equipment and improvement of farms and the reclamation of land."

If we add to this, further remissions, extra help to tenants, accumulation and writing off of arrears, the burden of unlet farms and of fixed charges, it is "clear that the net income of the landowner has fallen off to a far greater extent than is shown by a comparison of the gross rental now and at a former period;" and that "over a very considerable part of this country true rent has entirely vanished, since the owners are not receiving the ordinary interest upon the sum which it would cost to erect buildings, fences, &c., as good as those now existing."

Farming profits have fallen. Although in economic theory the farmer secures his "ordinary profits" before rent is paid, yet, practically, "it is obvious that the occupier will have a difficulty in adjusting his expenditure at once in order to meet the diminished returns, and, therefore, it is he who has to bear the brunt of adverse times, and, for a time at least, the greater share of the loss."

* This figure includes more than agricultural land (*e.g.* it covers ornamental grounds and gardens attached to houses, which, "probably, as a general rule, have not been falling,") and so under-estimates the fall in the value of purely agricultural land.

Rents are permanently revised, yet the fall in the value of the amount returned by the land has been continuous, and the revised rent, which might be fair for the moment, speedily becomes an extreme rent before further readjustment is made. What has to be remembered is that the farmer is an employer, and, to some extent, a capitalist. He usually sinks all he has in stock, manures, implements, &c. Where he has been long in a farm he also sinks his special skill—his special knowledge of the land and its requirements. These are forms of wealth which he cannot transfer easily or without loss. Taking the whole of the farm accounts received by the Commissioners as if they related to one business, it has been calculated that they show for the twenty years, 1875-1894, an average profit equal to 26·66 of the amount of rent and tithes, instead of 43·75 per cent., which was the old basis of estimation for purposes of income tax, or only "60 per cent. of the sum which was in past days considered an ordinary and average profit." The small arable farmer, perhaps, has, on the whole, suffered most. Mr. C. S. Read says:—"The only way in which he can possibly succeed is in doing the work of two agricultural labourers, and living at the expense of one. That is the only chance that he has, and I say that, as far as regards his family, they are worse educated and harder worked than the children of the agricultural labourer."

The position of the yeoman and small freeholder partakes of the hardships of both classes. As a rule, their properties, bought when land was high, are charged with mortgages, and "the mortgagee makes no remission of the interest due him." Thus frequently the interest is a heavier rent than would be paid to a landowner. In such cases the whole household is pressed in to do the farm work, and there are neither stated wages nor stated hours.

The position of the agricultural labourer is not so bad. In many of the eastern countries wages have, indeed, been reduced from 2s. to even 3s. per week, but in the remaining counties wages have not fallen. In Scotland the witnesses are unanimous that wages "have been well maintained." In Wales they appear to have definitely risen. But the depression strikes the labourer by curtailing the area of his employment as arable land is laid down in pasture, and by the greater irregularity of his work. "It is impossible," says the Commission, "not to regard with apprehension the continuous decrease in the numbers of the

agricultural labourers." While in twenty years the total population has increased by some seven millions, the labourers have decreased by a quarter of a million. "It is unnecessary to enlarge on the significance of these figures from the point of view either of the national physique or of the interests of the working classes engaged in other than agricultural industries."

Part II. of the Report is headed "Causes of Depression." The depression is not attributable to bad seasons, as was the case when the Richmond Commission of 1879 made its report. It is not ascribed to landlords' rapacity, nor to farmers' incapacity, nor to trade union agitation, and for the absence of these disturbing explanations we may be grateful. "Among all classes of agriculturists there is a consensus of opinion that the chief cause of the existing depression is the progressive and serious decline in the prices of farm produce." The figures of this decline are as follows:—

Wheat has fallen at least 50 per cent. Oats and barley have fallen nearly 40 per cent. On this the Commission says:— "With these facts before us it is difficult to see how the cultivation of cereals can be continued at a profit in this country except under specially favourable circumstances, as, for example, the proximity of good markets for the sale of straw." And Sir John Bennet Lawes says:—"In my opinion the end must be that the greater part of our arable land must go into grass. It is impossible to go on farming at the prices we have now, so far as I can see, even if the land is given up for nothing, unless it is very fine land indeed."

Beef has fallen 24 to 40 per cent.; mutton (since 1883), 20 to 30 per cent. Wool has fallen quite 50 per cent. Milk, butter, and cheese have fallen approximately 30 per cent. Potatoes have fallen 20 to 30 per cent. These figures, it should be remarked, are based on "the average prices of several years, in preference to the prices of single years," and the Commission has avoided "instituting comparisons between the prices now prevailing and those of 1871-4, which are sometimes regarded as having been exceptionally high."

The Commission concludes:—"We have no hesitation in expressing our entire concurrence in the opinion that the present crisis in agriculture is due primarily to the fall in prices."

The Commission then passes to the subject of Foreign Competi-

tion with these words:—"It is the opinion of many of the witnesses examined that the fall in prices has been directly connected with the increase of foreign competition." The facts of this competition are then given in great detail.

In twenty years the average annual gross imports of wheat, in the form of grain or flour, have increased by over 70 per cent., this increase being "accompanied by" a fall of 50 per cent. in the value. About 75 per cent. of our consumption is now of foreign origin. It is to be noted that this import indicates, to a great extent, a displacement of our producers, and not a mere addition to consumption. While the total consumption has increased, both absolutely and per head, the home supply has decreased, and the difference represents new supply from abroad.

As to the countries of origin:—the United States have been supplying upwards of 50 per cent. of the import; Russia and India, 23 and 25 per cent. respectively; while Argentina is now (1893-5) sending 11 per cent. It is noticeable that the land under wheat in the United States has "on the whole diminished." The area in the older-settled central and eastern States is contracting, while the area in the more newly-settled and western States is steadily expanding. On the great western farms machinery is "used within the closest limits of economy, and labour can be applied to the best advantage." The cost of production in North and South Dakota is said to be about 35 cents (1s. 5d.) per bushel. In California it is put as low as 22 cents (11d.). Two-fifths of the exports come from these three States. Mr. W. J. Harris estimates that wheat can be grown in California and exported to England at a net cost of 23s. or 24s. per quarter to the producer, including freight, insurance, cost of bags, and carriage from the farm to the shipping port; while from Manitoba a quarter of wheat can be produced and delivered in England at an inclusive net cost to the grower of 21s. 6d. The continued and undiminished export may be due, says the Commission, to exceptionally good harvests, or to the transfer of the growth of wheat from the exhausted to virgin soils. The evidence does not enable them to decide.

There are wide differences of opinion as to whether this competition from the United States can continue. One witness says that it will increase. Another, that it will continue so long as the price is at or about 25s. per quarter, and will enormously increase if it goes to 30s. A third says that it cannot go on for more than a year or two.

But Russia, the second largest contributor to our wheat supply, is reported to be likely to increase her exports, even at a price of 20s. per quarter in England. As to Argentina, the area suitable for wheat is immense, and it is claimed that no other country can produce more cheaply.

As regards barley, 44 per cent. of the consumption is of foreign origin. The import has increased, but only since 1893, and that irregularly. It comes almost entirely from the Continent; and one singular feature is the replacement of the dearer kinds of imported malting barley by an inferior grain from Russia, which is credited as making up 50 per cent. of the total import. "We are disposed to think," adds the Commission, "that the facts before us point to a material change having taken place in the nature of the materials used in the brewing industry." Here there is practically no displacement of the home acreage and crop, but what increased consumption there is is supplied from abroad.

Of oats, something pleasanter is said. In the first decade of the depression the foreign imports seem to have increased nearly 25 per cent., but for the last ten years they have slightly fallen off. The home acreage has not decreased, and the crop has rather increased. The percentage of foreign supply in the total consumption is now 19·6, as against 21·9 ten years ago. Seventy per cent. of the import continues to come from Russia and Sweden, Russia sending much the larger proportion. English oats have steadily fetched the highest price.

Of beans and peas the import is irregular, but, on the whole, tends to increase. The import of maize is singularly irregular; but buckwheat imports have doubled, and rye imports have quadrupled. These three latter do not directly compete with British producers as food grains, but, in so far as they are used in substitution of home-grown produce, they are "manifestly a competitive element affecting prices." "The price of feeding barley, as well as of oats, has been affected to some extent by the large consumption of maize."

As regards meat, the import of live cattle tended to increase up till 1890, but in recent years there have been indications of a decline. Its chief feature is the replacement of the Continental import by supply from the United States, Canada, and Argentina. The same replacement has taken place in the supply of sheep, but here the variations in the import from year to year "have been so great that no conclusive indications as to the course

of the trade can be drawn from them." But the import of live cattle, sheep, and swine is comparatively small, while the dead meat imports constitute about 25 per cent. of our total consumption. Fresh beef imports have increased from 1,732 tons in 1876 to 109,528 tons in 1895, 80 to 90 per cent. of this coming from the United States. Fresh mutton imports have risen from 9,500 tons in 1882 (when these returns were first separately shown) to 130,550 tons in 1895, Australasia sending us 60 per cent. since 1884, and Argentina, of recent years, 25 to 27 per cent. But in the case of this total meat import there has been little or no displacement of the home farmer. We produce about as much beef and mutton as before; the new supply from abroad apparently meets a new demand for cheap meat; "and while it has undoubtedly seriously affected the price of the inferior grades of British produce, its influence on the superior qualities has been much less marked." As regards pork, over 90 per cent. of the import takes the shape of bacon and hams, the chief source of supply being the United States. The proportion of the import to the total consumption is 48·8 per cent. The importation is irregular. The home production has remained practically stationary.

"It is clear that there has been a remarkable growth in the imports of meat during the past twenty years. Represented by its weight, the foreign supply of beef, mutton, and pork (live and dead), in the aggregate, has about doubled. Relatively to the population of the United Kingdom, it has risen from an annual average of approximately 22 lbs. per head in 1876-8 to 40 lbs. per head in 1893-5."

As to the future of this meat importation, we are told that there is not much prospect of a greater development of the importation of beef under existing conditions; but there are no indications of a diminution in the import of mutton, the evidence pointing rather to an augmentation of this trade, particularly in the form of frozen mutton. It is particularly worthy of notice, as one of the witnesses points out, that "the frozen meat trade carries with it the trade in butter, cheese, fruit, game, fish, and poultry, as well as that of other articles which need the help of refrigerators;" that "it has only been through the establishment of the frozen meat trade that the business in the other products has been initiated; and that it will only be by the extension of the frozen meat trade that the trade in the other products will be established and extended, for they

could not of themselves to any great extent afford to provide the necessary machinery, appliances, and accommodation."

The prominent feature as regards wool is that the gross import has nearly doubled in twenty years, and that the proportion of imported wool in the total supply has been steadily increasing. Although a considerable portion is re-exported, "about 70 lbs. out of every 100 lbs. of sheep and lambs' wool available annually for use in the United Kingdom is produced abroad." In this case, then, there has been some displacement of the home product.

In dairy produce, the importation of butter, margarine, and cheese represents more than 50 per cent. of our total annual consumption. The import of butter has nearly doubled in the last ten years, 50 per cent. being of Scandinavian origin; while of late years the lower-priced Australasian import — favoured by Government bounties — has been of very rapid growth. The import of margarine has shown few, if any, signs of development. There has been a slight increase in the import of cheese, the bulk of which comes from the United States and Canada, but no more than is sufficient to keep pace with the growth of population. It appears that the home production of milk relatively to the population has declined, and we must conclude that here also there has been some displacement. For this our methods of dairying and marketing seem very greatly to blame, and the Commission does well in calling attention to the fact that here there is no question of superior natural and climatic conditions abroad, and that, accordingly, the circumstances which have attended the growth of this particular competition are different from those before referred to.

As regards vegetables, fruit, poultry, eggs, and other articles, the statistics are not so full as in the case of the imports already referred to, but it is evident that the foreign supply of most of these products is increasing, and must be regarded as a serious element of competition. The supply of foreign eggs, for instance, has increased from 763,000,000 in 1876-8 to 1,426,000,000 in 1893-5.

The conclusion arrived at is:—"Contrasting the natural and economic conditions existing in the several countries mentioned above and in Great Britain, we fear that there is no near prospect of any permanent abatement in the pressure of foreign competition."

The Commission then passes to consider if there is not a corresponding and compensating change in Cost of Production

in this country. It is, perhaps, worth remembering that a fall in price does not necessarily hurt the producers of the article which falls in price. The profit, like the wage, comes indeed out of the price; but if the cost is reduced simultaneously and adequately with the price, there is no necessary injury either to farmer or labourer. The difficulty is where it is not possible, or possible at once, to adjust the outgoings to the reduced receipts. "It cannot be doubted that, with a continuous fall in the value of agricultural produce, the farmer finds it impossible at once to adjust his expenditure to his decreased returns." In farming, at least 30 per cent. of the cost consists of wages for manual labour. This item of cost has remained, as we have seen, almost constant. If so, it is clear that the labourer's share of the produce is greater than it was, and it is clear that the farmer has not been able to adjust this cost to the now reduced returns.

Nor does it seem that the farmer has got relief in the matter of feeding stuffs and manures, although "within the last ten years there has been a considerable decrease in the cost of cake and artificial manure, while the low price of corn has led to its being largely used in place of linseed or cotton cakes." It would appear from the evidence that "in several cases the amount expended on feeding stuffs and manures has largely increased." On 59 farms the average expenditure on these items was, in the latest year of account, not less than 22s. 3d. per acre, and "more than one-fourth of the whole of the farmer's expenditure for the year." The argument seems to be that higher farming is being demanded of the cultivator if he is to keep his place in the competition at all.

As regards two chief items of expenditure, then—namely, manual labour and feeding stuffs and manures—it is doubtful if there has been any adjustment of cost to decreased receipts.

Part III. deals with "Miscellaneous Subjects bearing on the Agricultural Position." These are—The Agricultural Holdings Acts, Land Tenure, Rents, Sale of Mortgaged Land, Tithe Rent-charge, Dairying, Small Holdings, Railway Rates, Game Laws, Commercial Gambling, Sale of Adulterated Products and Sale of Imported Goods as Home Products, Sale of Cattle by Live Weight, the Board of Agriculture, Agricultural Education.

Part IV. contains a "Summary of Recommendations," based on the above. They are confessedly "not a complete remedy," but

"in the nature of palliatives," such as amendments to the Agricultural Holdings Acts, remission of tithes, reduction in railway rates, changes in game laws, technical education, and public loans for agricultural improvements. The Commission think that, if such recommendations are attended to, "it is not unreasonable to believe, even with the present low level of prices, that the land of Great Britain, which is reasonably favoured in point of either quality or situation, will continue to be cultivated, in grass if not as arable, and will yield a profit, reduced indeed and more hardly gained, but fairly comparable, all circumstances considered, with that earned in other departments of industry." But if the foreign competition is maintained and prices still fall, they "must look forward to a further reduction of the area of British land susceptible of profitable arable cultivation, together with a corresponding contraction of our production, and a diminution of our rural population."

Such, then, very briefly condensed, is the Report signed by fourteen of the sixteen Commissioners. It closes with the words:—"We have agreed nearly unanimously up to this point. But upon the remaining subject of discussion—viz., whether any, and, if so, what remedy or remedies might be possible for the chief cause of depression—there is considerable difference of opinion amongst us, and we think it desirable to close this part of the report at its present stage, leaving the subject to be dealt with in separate memoranda."

Following this comes a Supplementary Report. It is important to note that this is *not* a Minority Report, signed by members who do not assent to the principal one, but, as it is stated to be, a "Supplementary" Report, signed by ten members of the fourteen who sign the other. Two members agree in neither of these Reports, and issue separate ones of their own.

In what I have further to say I propose to confine myself to the first and unanimous Report.

There are two respects in which this Report strikes me. The first is a minor matter, but it is suggestive: it is the uncertainty of its tone as to whether agricultural imports are to be welcomed or deplored. I do not find that the consumer's interest is even mentioned. The Report is sympathetic over

the loss or ruin of landowners and tenants, but it says nothing about the other side of the question—namely, cheap food. Indeed, on page 41 occur these words:—"A satisfactory feature of the past year was the rise in the prices of grain." We have these many years been congratulating ourselves that Free Trade has given us unlimited supplies of cheap food. And here, in the last days of the century, is a representative Commission expressing its gratitude that food is likely to be dearer! Without expressing any opinion as to how far cheap food compensates for a ruined agriculture, I venture to say that this seems a notable advance, in parliamentary inquiries, towards the recognition that the producer and the consumer are one person, and that putting into one pocket while taking out of the other is scarcely the way to fill both.

The second, and the chief respect in which this Report strikes me, is that it shirks what, to my mind, is the principal question. The depression is traced "primarily" to the fall in prices. But nothing is said as to the ultimate cause or causes of this fall. I do not say that the question is an easy one. From the Supplementary Report and separate memoranda one may infer that the fourteen Commissioners would not have agreed as to the ultimate cause. But they might have been unanimous at least in pointing out that there *is* such a question underlying any "primary" explanation of the depression. The omission is all the more striking that Sir Robert Giffen has, as we shall see, given so strong an opinion on it. As it is, we have only this pronouncement:—"The grave situation we have described is due to a long continued fall in prices. This fall is attributed by the great majority of witnesses to foreign competition." But on this the Commission itself, in the Report under consideration, gives no opinion. Thus the impression is left on the reader that the Commissioners homologate this attribution; and only those who go on to the Supplementary Report and the special Memorandum of Sir Robert Giffen find that this is not the case. As it is, this first Report is apt to be accepted as a Majority Report in the usual sense of being opposed to and by a Minority Report, and, as every one knows, the Majority Report of a Royal Commission has a way of being accepted by the public as the authoritative one. This is particularly misleading when, as in the present case, it stops short of and does not discuss a question which must have been in the minds of all the Commissioners.

What I wish to do is, first, to explain why the fall in prices is attributed "by the great majority of witnesses" to foreign competition; and, second, why the Commission does not homologate this.

It is scarcely to be wondered at that foreign competition should bulk most largely in the eyes of those interested in agriculture. There is a special feature in our agricultural depression which makes it a proper subject for a distinct inquiry. In all departments of manufacture we have had a fall in prices during the last twenty years; not, perhaps, quite so great a fall, but still not very far from it. But we have not had, simultaneously with that fall, any very striking increase in our imports of foreign manufactures. The competition from which our manufacturers have suffered is competition in foreign and neutral markets; and in this case we fix our attention on the diminution of our exports. But the competition from which our farmers have suffered is a competition of foreign producers selling in our own home market; and what attracts our attention is the imports into this country of produce similar to what we raise at home.

This being the peculiar characteristic of agricultural competition, it is natural to connect these increasing imports of foreign produce with the fall in prices as cause and effect. What we have, however, to examine is, if the *post hoc* is really the *propter hoc*.

It is asked, Why do agricultural prices fall? The unhesitating answer is this—Because, under Free Trade, we have called in the whole world to compete with our farmers. Other countries can raise produce more cheaply than we can; therefore prices must go down.

Is this true? Is it the case that, when two goods meet in competition, the one which has the lower cost [illegible] the one which has the higher? The terms of Ri[illegible] law might have reminded us that the goods wh[illegible] can drive out the goods which cost more only [illegible] enough to take off both at a pr[illegible] remune[illegible] latter. Where demand is suffici[illegible] the producer's surplus or ren[illegible] costly supply and a fall in [illegible] produce more cheaply tha[illegible] it, that they should und[illegible] only through supply.

cannot get the old price; and the only reason why they [illegible] not get the old price is that they over-supply the market at the old price.

What is the meaning of over-supply? In some very [illegible] it may mean that more is offered for sale than people [illegible] most cases it simply means that the demand does not [illegible] fast as the supply. But is it self-evident that [illegible] generally outrun demand? It is believed so in [illegible] Business men seem hypnotised by the conception [illegible] I do not wonder at it. In most trades there [illegible] over-production. But the strangeness of this [illegible] out when once the fact is grasped that over[illegible] under-consumption. One side of the shield is [illegible] more than I can sell. That is my side. [illegible] you are not buying more; and the question [illegible] more. You answer, "Because I do not want [illegible] true? Not in the least. You do want [illegible] "Ah, yes," you reply; "of course, I d[illegible] unless you reduce your price." I [illegible] Would you not buy more if you [illegible] But, on their own confession, men [illegible] with. They may not, indeed, have [illegible] only the intermediate "value carrier [illegible] phenomenon, according to the [illegible] producing too many goods, [illegible] But if there is over-production [illegible] every warehouse, is this not [illegible] necessary, after all, to demonstrate [illegible] of supply is, at the same time [illegible] of demand?

That it is so is quite clear to anyone who will give the trouble to understand that [illegible] familiar in economic science [illegible] National Dividend [illegible] annual product—the [illegible] we [illegible] for us by for[illegible] [illegible] the sum an[illegible] [illegible] nation's an[illegible] [illegible] understand this. [illegible] th [illegible] and lim[illegible] g us [illegible] all we can ge[illegible] this [illegible] foreign [illegible] xchange [illegible] get [illegible] changed [illegible] your

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Is this true? Is it the case that, when two goods meet in competition, the one which has the lower cost drives out the one which has the higher? The terms of Ricardo's rent law might have reminded us that the goods which cost less can drive out the goods which cost more only where there is not demand enough to take off both at a price which will remunerate the latter. Where demand is sufficient, the result is a difference in the producer's surplus or rent; not a displacement of the more costly supply and a fall in price. That the United States can produce more cheaply than we can is no reason, on the face of it, that they should undersell us. Cost of production affects price only through supply. Importers let down their price only if they

cannot get the old price; and the only reason why they should not get the old price is that they over-supply the market *at* the old price.

What is the meaning of over-supply? In some very few cases it may mean that more is offered for sale than people want. In most cases it simply means that the demand does not increase so fast as the supply. But is it self-evident that supply must generally outrun demand? It is believed so in business circles. Business men seem hypnotised by the conception of over-production. I do not wonder at it. In most trades there is what is called over-production. But the strangeness of this phenomenon comes out when once the fact is grasped that over-production means under-consumption. One side of the shield is that I am producing more than I can sell. That is my side. The other side is that you are not buying more; and the question is why you do not buy more. You answer, "Because I do not want more?" Is this true? Not in the least. You do want more of almost everything. "Ah, yes," you reply; "of course, I do. But I cannot buy more unless you reduce your price." I ask again: "Is this true? Would you not buy more if you had more to buy with?" But, on their own confession, men generally have more to buy with. They may not, indeed, have more money, but money is only the intermediate "value carrier" of goods, and the usual phenomenon, according to the business man, is that makers are producing too many goods, and they call it over-production! But if there is over-production all round, and unsold supply in every warehouse, is this not the "more to buy with"? Is it necessary, after all, to demonstrate that every increased amount of supply is, at the same time, an increased amount of demand?

That it is so is quite clear to anyone who will give the trouble to understand that conception now familiar in economic science as the National Dividend. The national annual product—the sum of the goods we make and get made for us by foreigners who have borrowed our capital—is, of course, the sum and limit of the income we British have. It is the nation's annual supply of goods and services. We all understand this. What we do not so readily perceive is that it is the sum and limit of the nation's annual demand. It is at once all we can get for our living and all we have to buy our living with.

To understand this we have only to get below the money form of the income. You make and fill your cart with certain produce

and bring it to market. I make and fill my cart with certain other produce. Suppose that we are the only dealers, the total supply in the market is the sum of what our carts contain. But my demand is what I bring in my cart, and your demand is what you bring in your cart, for we are making for and exchanging with each other. These two cartloads are the total demand of the market. But we have just seen that they are the total supply of the market. Supply and demand are one and the same sum of things. It is usually said that every increase of supply brings out a corresponding increase of demand. The accurate statement is that every increase of supply *is* an increase of demand.

This essential identity of supply and demand we are forced to admit, whenever we get behind money and money price to the great exchange of goods against goods which money makes possible and reflects. Each supply goes seeking other supplies as a demand for them; the same goods masquerade now as supply, now as demand. But if each new supply is a new demand, we are still without an answer to our question, why it should be so readily assumed that supply generally outruns demand.

Thus far, however, we have looked at demand as goods; picturing to ourselves the market as a kind of clearing-house where demands are set against each other and demanded of each other. We have now to remember that, while demand is indeed goods, it is goods in the hands of a demander—a human being with wants of various intensities and various degrees of realised satisfaction; a demander, moreover, who seeks goods not only for his personal consumption, but for making other goods to satisfy other consumption. Thus these various "demands," which, together, constitute the total supply of the market, may not be able to come to terms with each other; and, in any case, the ratio of exchange at which they do come to terms is constantly changing. For the value of each demand is assessed, not by the individual demander, however accurately he may make his calculations, but by the market. Thus it comes that although, in normal circumstances, each increase of supply is an increase of demand, the value placed by the market on the new goods may be very different from the *amount* of the goods; and we have the phenomenon of, perhaps, a great increase of supply translated into a very small amount of demand: in other words, we have a fall in the exchange value of the goods in question. This is what we mean by supply outrunning demand. We do not, as a rule, mean that the supply is not taken

off the market, but that the ratio of its exchange has to be altered to its disadvantage before it is taken off. This brings us to the fundamental fact contained in the very conception of exchange value; that, where any goods are exchanged against each other, if the value of the one group rises, this means nothing else than that the value of the other falls.

Now let us apply all this to our present problem. As it happens, it is more easily applied in this case than in internal exchange.

International trade, as we all know, is, fundamentally, barter, and here, if any where, we should expect to find the identity of supply and demand manifesting itself. Where there are no complicating circumstances, such as payment for carriage, international debts, and the like, the imports of a country are a demand for its exports, and the two pay for each other. Let us suppose, then, that Great Britain and the United States traded with each other solely and directly, we sending cloth and America sending wheat. In this case no matter how much wheat America sent us, the exchange value would not alter so long as she took from us a proportionate increase of cloth, and this applies both to the units and the totals. A yard of cloth and a bushel of wheat would have a fixed value as priced in each other. This is not a deduction: it is simply an explication of the conception of exchange value.

Well, the question suggested is;—Why is not the increase in the supply of foreign produce—in our agricultural imports—an extra demand for all the goods that we export? If it be answered that it has been so—that we are paying for more grain with more manufactures; then I ask—What has this to do with, or how does it explain, the fall in the money price of produce? England and America are demanding more from each other, and are each supplying more to the other. If the bushel of wheat still exchanges for the same number of yards of cloth, does this give us any explanation of the fall in the price of the wheat?

To put it concretely—say that America was sending us x wheat when the price of x was 40s., and we were paying for it by y cloth when the price of y was 40s. Suppose that she is now sending us $2x$ wheat and we are paying for it by $2y$ cloth, how does this explain the fact that x wheat is now 20s? How can foreign competition explain a fall in *price*, if there is no fall in exchange value on either side, but only an increase of amount exchanged on both sides?

At this point I must recall your attention to what our problem really is. Many people think that our home produce is being replaced by foreign produce; that we now import what we formerly grew or made. This is the case with wheat to a considerable extent, and with wool and milk to a smaller extent. And, further, as population and wealth are always increasing, there actually is replacement to the extent that our home produce has not increased proportionally. This replacement presents us with a problem of its own, and calls for an answer of its own.

But, from the statistics given, you will have noticed that, for the most part, our farmers have been producing just as much as ever. Thus, with the exceptions noted above, the problem is that of a *new* supply from abroad; and my question is—Why is not this new supply of imports a new demand for exports? Or, if it is the case that this increase in imports has really been balanced by a corresponding increase in exports, why should money prices fall?

If we press home this question we come, I think, to the common belief that the fall in the money price of farm produce reflects truthfully a change in the ratio of exchange between agricultural produce and manufactured goods generally. It is assumed that our consumption of agricultural produce is sternly limited by the fact that each individual among us has only one stomach and one digestive system.* The fact is true: the inference is questionable. Not only are immense numbers not yet sufficiently fed, and not only are agricultural products used for many things outside of food—*e.g.*, as raw materials for manufactures — but the natural progression of human wants is from quantity to quality, and we steadily make more demands on agriculture and its produce to give us varied and finer food.

But suppose we grant the inference to the fullest extent. Suppose we say that there is not the same elasticity in the demand for food stuffs that there is for goods in general; that, accordingly, if food stuffs have been pressed on our market their exchange value, as against goods in general, must have altered considerably for the worse. What this means and involves—according to the

* Sir Robert Giffen, *e.g.*, suggests that "the decline in the price of wheat may be partly attributed to the great increase in the supply and consumption of meat during the last twenty years, which has either diminished the demand for wheat per head among the people consuming wheat, or has checked the increase of that demand which might have been expected to follow a great decline in price."

very conception of exchange value—is a rise in the value of those goods with which we buy food. We shall be giving only the same amount of manufactures for more food stuffs. If this were faithfully represented and expressed in money figures, it would mean that prices of food fell while, and as, prices of manufactures remained steady.

On such an assumption foreign imports *might be* the sufficient cause of falling prices of agricultural produce, but only on one condition—namely, that prices of our manufactured exports did not fall.

But the fact from which we cannot escape is that prices of manufactures have fallen also. The phenomenon to-day is not a fall in the value of agricultural produce balanced by a rise in the value of everything else. It is a universal fall in price—that is to say, in money price.

The conclusion to which I feel bound to come is that, in treating of the fall of agricultural prices alone, the Commission will have strengthened the popular conviction that foreign competition is responsible for the whole fall. If it had gone on to connect its evidence with, say, the proofs led before the Labour Commission, and witnessed to in the index numbers, that all prices have fallen; then foreign competition, in the shape of increased imports of produce meeting a comparatively limited consumption, would have fallen into its true place as an aggravating circumstance peculiar to agricultural prices. Suppose—to put it roughly and for illustration's sake—it had been demonstrated that agricultural prices have fallen 50 per cent., while general prices have fallen 38 per cent., then the evidence would have been taken to explain why the former prices have fallen 12 per cent. more than the latter. But, as it is, the Commission has left the public to draw the inference that the whole fall is due to foreign imports. In times when the agricultural interests are only too ready to imagine that foreign imports can be prevented, as other countries have prevented them, this seems to me a little dangerous.

Fortunately one member of the Commission has done his best to correct this inference. In his evidence, and in a separate memorandum, Sir Robert Giffen goes to the root of the matter. He claims that he anticipated this fall as far back as 1872. At that time the United States and Germany were making demands for the standard money of this country to the amount of something

like £200,000,000, and he then said that the redistribution of the sum of gold over a larger area could not be made without a sharp contraction in the scale of prices. This demand, of course, did not cease in 1872, but has been followed by other demands.

"To what," he was asked by the Commission, "do you attribute the fall in agricultural prices?"—"Chiefly to the same causes that have produced the fall in general prices." "What might they be?"—"The contraction of money relatively to what went before." "Had it nothing to do with foreign competition?"—"I do not think foreign competition is on the same plane with changes in prices. I believe that foreign competition would affect us whatever the scale of prices might be."

Indeed, he has never said anything else. His doctrine is that we are doomed to falling prices in the nature of things. As the belief and practice of mankind are to-day we must have the basis of money in precious metal. Now, however abundant the supply of precious metal, it is after all only one thing, and what it has to do is nothing less than to mirror all the exchanges and name all the exchanges for all things. But as the population of the world is increasing fast; as its wealth and the exchanges of that wealth are increasing faster; and as savage and undeveloped peoples are rising into exchanging communities faster still, it is inconceivable that the increase of our precious metal money can be as great as the increase in the work that is being put upon it. It is for this reason that Sir Robert claims—and rightly claims—that he anticipated the fall a quarter of a century ago.

It will be seen, then, that what I have said above is in agreement with the contention of our great statistician, that the great fall in agricultural prices is not an isolated phenomenon, due to circumstances peculiar to agriculture, but a part of the general fall. In every department of industry there will also be changes in price from the side of supply and from the side of demand: in agriculture particularly there will be quite special changes, owing to the enormous increase in supply as against, possibly, the physical limitation to the consumption of food products. But, underlying all changes, there is one cause which affects the general level of price: that is, a change in the relation between the money supply and the commodities exchanged. There is no objection, indeed, to saying that foreign competition is the cause of the present agricultural depression. But why is it so? Because this competition is one form of the enormous multiplication

of commodities. But general falling prices are not explained by multiplication of commodities unless the amount of money available is unable to keep pace with the work it has to do in naming and exchanging these commodities.

This, then, is the somewhat unsatisfactory position assumed by the Agricultural Commission. Fourteen members sign the first Report, and leave the critical question unstated. Then ten of these sign a Supplementary Report which not only states the question and answer, but declares strongly for a particular remedy. Sir Robert Giffen stands aside, and, while agreeing with the bimetallists that this is a currency matter, says that there is no remedy.

For my part I think that, to give up the idea of a stable standard—to say that we are for ever doomed to falling prices, illumined by temporary breaks of rising prices—is to fold our hands resignedly under a blight. I am no advocate of rising prices—although every business man is in his own individual trade—but I am not able to see how any man who employs fixed capital and is under fixed or not easily adjustable charges is able to prosper under a regime of falling prices. Falling prices are the despair of the employer; and let me remind you that it is with the employing classes, the manufacturers and the farmers, that the organisation of labour lies. To discourage the employers—to make theirs always the losing hazard—is to make more swiftly for monopoly than one realises, for it is making it impossible for the ordinary employer to make a profit except by entering a combination for the purpose of keeping up prices artificially.

What are the industries most hit by falling prices? Of course, those that work with the greatest amount of fixed charges:—charges for capital sunk and unremovable; charges for money borrowed; charges for taxes; charges for contracts to pay, which extend over years. It is because the industry most under the burden of fixed charges is Agriculture that we have depression so marked and so emphasised that we have had a special Commission to investigate it.

Among these fixed charges in all businesses is one of which we think too little: it is the fixed charge called Wages. Let me conclude by pointing out what is going to be the consequence of falling prices in this regard.

It is a statistical fact that a fixed sum of money, buying at

wholesale prices, can, to-day, obtain some 62 per cent. more of commodities generally than it could twenty years ago. This does not necessarily mean that any one is better off by 62 per cent.; for it may happen that he spends some or much of this income on the things that have not fallen, such as house rent in poor and congested districts,* and it may be the case that employment is more irregular. Besides this, for reasons which I cannot very well make out, retail prices do not seem to have come down in the same proportion.† But, even if the proportion is much less, the buying power of a fixed income is very much greater than it was.

If, then, it is the case that the one class of money income, of which it can be said with certainty that it has, at least, not fallen, is the wages of the working classes, it is clear that the real wages of this class have risen by a considerable percentage. But the working classes do not know this; and, when it is told them, they do not believe it. One thing they do know: that the wealth of this country is increasing hand over hand, far outstripping the growth of population. The conclusion they base on this is that they should have steady rises of money wage. It is a tradition that has come to them from the years before 1873, when prices were rising; and they have no idea that there is any reason why money wages should not rise now as they did then. At a representative meeting of working men, lately called to consider the effect of women's cheap labour on men's wages, one of the delegates remarked that he was not aware that there had been

* I am reminded that rates and taxes have not fallen. But these are, normally, a payment for municipal and government services. That these have immensely improved, and that we are thus paying the same price for better services, I make no question.

† This is a matter on which strong assertions are made on both sides. It is confessedly difficult to get statistics of retail prices which will apply to the same place, the same class of purchasers, and the same quality of goods. But it is inconceivable to me that retailers generally should be earning a larger profit now than they were twenty years ago, or that the expenses of distribution should have greatly increased in years marked by the rise and growth of great stores, co-operative and otherwise. In the usual comparison two things are forgotton: the general—though not universal—improvement in quality, and the fact that innumerable things are now within most people's reach, which formerly were not to be had at all. Compare, *e.g.*, the old bicycle with the modern "safety." And I cannot help thinking that many compare retail prices now with the wholesale prices of twenty years ago, instead of with the retail prices of twenty years ago.

any change in the wages of his trade, adding naively, as an afterthought, "except, of course, a rise now and then." If they do not get this rise they will strike and go on striking, because they do not know—and I must say they are seldom told—that their wages *have* risen, and that this rise is reflected in their standard of life.

Now, while most people will rejoice that their standard is rising, it is quite possible that this rise should be too rapid. I do not mean too rapid for their good or for our wishes, but that it may be at the expense of other factors whose loss or discouragement may have far-reaching effects on the national industry. I am not able to see that the steady discouragement of the private employer, and the consequent tendency towards combination and monopolies, are likely, in the long run, to be in the interest of the wage earners. In any case, it is a misfortune that this real rise in wage should be unnoticed by them. Their ignorance of it inclines them to listen to those who are always too ready to tell them that they are not getting their share of the increasing wealth.

What I have to remind you of is, that this Standard of Life is a thing that can scarcely be set back. It is bound up in the affections of the trade unions with the minimum wage. I do not think that any one need hope now to carry a general reduction in money wages, for the money wage that rules has come to be thought of as the "living wage," and every attempt to reduce it will be met with the cry and the conviction that it is an attempt to crush down the worker below subsistence level. But there is a way in which this can be evaded, and is being evaded; it is by replacing men by women in many occupations which are yet in the hands of men.* In innumerable cases women can do as good work as men, and their money wages may rise a long way before they come up to the minimum wage of men. I express no opinion upon this here, but I cannot help thinking that this fall in price has given the women workers a chance which they never had before. But it is quite clear that the entrance of women into the men's trades is the beginning of a new struggle and a long struggle—with capital this time as the ally of the women.

* The possibility of such a competition has scarcely entered the minds of our working classes generally. But I am informed by one of my colleagues that certain costly and delicate tools for scientific instrument making, which are literally not to be got in this country, are being made in France in the engineering shops very largely by women's labour.

II.—*Life and Thought of Anglo-Saxon England as preserved in Contemporary Poetry.* By JOHN CLARK, M.A., English Master, Glasgow High School.

[Read before the Society, 1st December, 1897.]

A FULL account of the manners, customs, and cast of thought of the Anglo-Saxons would presuppose an examination of all their literature and of all the historical and other documentary evidence regarding them in their continental as well as in their English home. It would involve, moreover, the consideration of all their Runic Remains and Burial Mounds, and even the discussion of the question, how far existing phenomena are attributable to, or a modification of, older conditions and mental attitudes.

Thus the complete solution of the problem is far beyond the limits of our present purpose, which is rather to glance at a few of their characteristics—basing our remarks on their poetic literature, and introducing the evidence of other matter as subsidiary, explanatory, or illustrative.

Now the period embraced by their poetry is far more than co-extensive with these six hundred crowded years, beginning, as is commonly maintained, with Ebbsfleet and Aylesford, and certainly ending with that fatal day at Hastings, when the flower of Saxon chivalry fell before the fierce onset of the tanner's fiery grandson, and we must keep this in mind if our view is to be either clear or comprehensive. For the beginnings of their life we must turn our eyes to that older England beyond the North Sea, and for the written confirmation of poetic allusion and stated fact we must study the somewhat meagre testimony of writers outside the pale of English literature altogether. In this connection, it is most unfortunate that we should have lost the exhaustive treatise of the elder Pliny, who, on all matters referring to the Germanic tribes, was especially qualified both as to the stating of facts and the expressing of opinion. The two best-known writers left to us are Cæsar and Tacitus, and in estimating even

their testimony we must bear in mind that their remarks often apply to characteristics not found among the Teutonic people as a whole. We must remember, too, that Tacitus has been accused of pointing a moral for his degenerate countrymen by making a Germanic virtue of every Germanic necessity. All the same, when we read their pages, and compare the general tenor of their assertions with the remains of minstrel art that have been rescued from the silent stream of time, we are astonished to find how many of the characteristics of that early age are retained and exhibited in poetry the oldest portions of which took *written* shape more than six centuries thereafter, and how little many facts of Anglo-Saxon life have differed in their essentials throughout these long years. We see, moreover, how many existing institutions were already present in the germ, and how, despite the fact that throughout the ages we have culled all that was best both from those we conquered and from those who conquered us, yet, whatever else we are, we remain even to this day, in customs as in language, essentially Teutonic, in spite of the assertion of Matthew Arnold that England is "a vast obscure Cymric basis, with a vast visible German superstructure,"[1] and it is this unbroken continuity of our national life that enables us to reconstruct the facts of these early days, and in some measure to show what was due to purely native genius and what was dependent upon new factors—when, for example, the Saxons came into close contact with Christianity and Roman culture, when their simple cast of thought was affected by the wisdom of the schools, and their primitive art by the odour of the lamp. Still, owing to the long lapse of years, and to the fact that so much of our information is at second hand, we must beware lest we create a mere thing of shreds and patches that in manners and mode of life cannot claim to be a Teuton, or, for that matter, a man at all, but a mere clothes-horse on which to air a few attenuated and antiquated garments. To avoid this we must introduce nothing that has not some well-grounded authority in their own literature, or in the sifted statements of other writers, or in the work of archæologist and antiquarian, through whose efforts the spade has often revealed the greatness that the sword upbuilt. All these safeguards are necessary, for even the native *written* record is not contemporaneous with the event, and we are often at a loss to

[1] "Celtic Lit.," p. 64.

know how much is coloured by the culture of the scribe or exaggerated through tradition—that great magnifying glass of antiquity.

From these preliminary remarks and cautions we proceed to our inquiry, and in the consideration of their mode of life we are first of all impressed by the fact that the Saxons brought with them from their continental home that dislike of cities and that desire for isolation which seems to have characterised the Germanic tribes.[1] Indeed, though Wright throws doubt upon the point,[2] it seems proved that they gave over to decay the towns they had taken from their Celtic enemies, and the evidence given by the nomenclature of the towns themselves would relegate their origin to the later times of peaceful settlement. Thus we find each individual community shut off from every other by that dread belt of forest waste, the "mearc" or markland. This was at first under the protection of the gods, who, as the epithet *metod* (*i.e.*, measurer) shows, were intimately associated with boundaries. And such was the sanctity of each chiefship that long after Christianity had removed the "mearc" from the jurisdiction of the gods, it was still held sacred by English law, and a stranger as soon as he entered it had to blow his horn, or otherwise herald his approach, if he did not wish to be taken for a thief or an enemy, and summarily punished.

Let us now examine one of these isolated communities. Let us see the picture of the so-called Kingly Hall and its customs, which their Heroic or Saga poetry has preserved for us. Such settlements were situated by the coast, usually near a bold precipitous headland, which stretched far out to sea, and formed a fiord with safe anchorage, but not easily accessible. On the summit of the cliff was stationed a stalwart coastguard, whose duty it was to give timely notice of an approaching ship. From the strand, a path, sometimes stone-paven,[3] led up to the Hall, which stood in a fertile plain but close to the edge of forest and moorland. Its twin gables, like ears and snout, gave it a quaint appearance in the sunlight, so much so that in the old Icelandic poetry it earned the epithet of "Bruin with the floors."[4] Though built of wood, it was strong enough to withstand any power

[1] Tacitus, "Ger.," 16.

[2] "Celt, Roman, and Saxon," p. 510.

[3] "Beowulf," 320—for whole description *cf.* "Beo." *passim.*

[4] "Corpus Poeticum Boreale," II., 455.

except that of fire, and this danger was obviated by their isolation. In connection with these *wooden* edifices, it is interesting philologically to note that the English word "timber" (cf. A.S. *timbran, timbrian,* Goth. *timrjan,* to build) is actually the Latin *domus,* and so philology throws a side-light on history, for *stone* buildings were regarded by the earlier Saxons as something altogether mysterious. This is shown by such references as "wondrous wall-stone," "wondrous work of giants," &c.

The Hall had two doors. On the outside, by the main entrance, was a bench, whereon strangers seeking an audience sat, and where, on their admission to the royal presence, they left all their arms, except helmet and war-harness.[1] This was the universal custom of chivalry even to a much later day, for we read in the "Boke of Curtesye" (*circa* 1430) :—

> "When thou comis to a lordis gate,
> The porter thou shalle fynd ther ate :
> Take hym thou shalt thy wepyn tho,
> And aske hym leue in to go."
>
> (Quoted Earle's "Beowulf," p. 120.)

And that the same habit was found in Northern Europe is proved by the provincial Swedish name for a church porch, viz., *våkenhus* (*i.e., vapenhus,* weapon-house), which is derived from this very custom.[2]

The principal door was at the west, and directly facing it were the fire-hearths, to right and left of which were the tables and benches, and along the walls behind these were webs or tapestries,[3] which seem to have been used for decoration comparatively early in Teutonic history. At right angles to these tables ran the dais, whereon was usually the High Seat, on which sat the king and his queen. Here, too, seems to have been a cross table, at which the ladies of the household probably sat, though their duty lay rather in attending to the guests. A small private door generally opened on to the dais. The tables on the left hand of the main door were the least important. The exact position of the High Seat is difficult to determine. Indeed, it seems to have varied with the structure of the halls, some of which wanted the dais altogether. As regards Heorot, the best

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[1] "Beo.," 325, 397.

[2] Earle's "Beo.," p. 120 (authority Stephens).

[3] "Beo.," 995. (For details *cf.* "Beo." *passim;* and Vigfusson, "Icel. Reader," p. 357.)

specimen preserved to us, Heyne would place the High Seat close to the great central pillar, which, like the olive tree of Odysseus,[1] rose in the centre of the hall. At the king's feet sat his orator or raconteur, a man of some importance, but liable to be supplanted[2] by one who brought to the hall a greater gift of minstrelsy. That this custom was well known, even at a later day, is strikingly shown by what we find outside Anglo-Saxon literature altogether. For example, in the "Romance of Sir Tristrem," we read:—

> "An harpour made alay,
> That tristrem, aresound he.
> The harpour gede oway:—
> 'Who better can, lat se.'
> 'Bot y the mendi may,
> Wrong than wite y the.'"

Then, after Tristrem plays, we read:—

> "The harpour gan to say:—
> 'The maistri give y the
> Ful sket.'
> Bi for the kinges kne
> Tristrem is cald to set."
> (Ed. M'Neill, S.T.S., p. 16, ll. 551-561.)

Here we see not only the custom, but the actual process of supplanting, in which the minstrel himself acquiesces.

Then as to the disposition of the guests, we find that the young men sat together and apart from the elders,[3] probably on the least distinguished bench. The etiquette of the Hall was that the queen took the "twisted" cup—actual counterparts of which have been found in Saxon graves[4]—and first of all presented it to her lord.[5] Then she passed it to the guests in order of precedence. But if a distinguished stranger was present, he seems either to have occupied a set place, probably, as Heyne suggests, on a bench of distinction opposite the throne, or to have stepped forward to the throne, after the others had drunk, and there to have received the cup at the hands of the queen.[6] At such banquets, too, gifts, often as a reward for deeds of prowess, were presented not only by the king,[7] but also by the queen,[8]

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[1] "Odys.," xxiii., 190.
[2] "Deor.," l. 40.
[3] "Beo.," 621, 1190.
[4] Jewitt, "Grave Mounds," p. 230, figs. 356, 357.
[5] "Gnom. Verses," 89-93.
[6] "Beo.," 615.
[7] "Beo.," 1023.
[8] "Beo.," 1218.

who gave her own special gifts to those whom she delighted to honour. This was part of their time-honoured ceremonial, and helps to illustrate the high place held by women among the Teutons, which is so wondered at by Tacitus.[1] It crops up again and again in the "Beowulf." We see it, too, in the "Niebelungen Lied," where we behold the queen of Siegfried performing a similar duty:—

> "The gorgeous feast it lasted till the seventh day was o'er;
> Siegelind the wealthy did as they did of yore,
> She won for valiant Siegfried the hearts of young and old,
> When for his sake among them she showered the ruddy gold."[2]

But we have dark pictures also of drunken revelry, and none more notable than the feast of Holofernes.[3] Nor is bloodshed always absent, for we have many a loud-voiced discussion over the mead-cup, with clash of sword for argument[4]—an *argumentum ad hominem* neither unknown nor ineffectual in these early days. But the poet loves rather to dwell on song and glee, when the harp was passed from hand to hand, and the guests listened to tales of long ago. Each one added his quota to the social merriment: even the king did not disdain to tell some wondrous tale, and the age-bound warrior fought again the battles of his youth,[5] and thus the evening deepened into the night. When the feast was over, the preparations for sleep were of the simplest: the benches were merely removed, and in their place were strewn beds and bolsters, on which the warrior slept, with shield and buckler by his head and helm and shaft by his side, for it was their custom ever to be ready for war, both at home and in the field, on whatever occasion their lord had need of them.[6] The ladies meanwhile retired to their own apartments, for we find here the distinction between "bower" and "hall," which to this day is retained in romantic verse.

Let us next look into the simpler life of our forefathers on farm and garth, as we see it set down in their homelier pieces, such as the "Riddles" and the "Crafts of Men." When we advance to these later settled times we are struck by the change the face of the country has undergone. The settlements are no longer perched on a fringe of rock-bound coast, but stretch far up

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[1] *cf.* "Ger.," 7, 8, 45.

[2] "Zweites Abenteuer," § 42, trans. Lettsom.

[3] "Jud.," 15 *et seq.*

[4] "Fates of Men," 48.

[5] "Beo.," 2105 *et seq.*

[6] "Beo.," 1239-1250.

into forest and moorland. Where the dragon once lurked the peaceful herd now roams. The axe cleaves the wood of the forest rather than the helmet of the foe, though now and then a sudden inroad calls to life again that time-honoured function. Let us try to reconstruct one of these hamlet settlements. The "mearc" has still to be traversed, the horn has still to be blown, but, when we step out into the sunny meadow, its characteristics are those of peace. True, the gallows-tree is still found close to the markland, but is the outward symbol of law and order, though sometimes, doubtless, it meted out "Jeddart Justice" to the alleged offender. In front is the homestead, with the huts of serf and dependant clustered round. Behind, the ox is grazing;[1] in front he pulls the plough, which, guided by the "hoary foe of the holt," is upturning the turf and covering its green sides.[2] On the track of the ploughman comes the sower.[2] In the field the labourer wields the rake.[3] Beside the farm-buildings is the draw-well, with the dusky Welsh slave and her water-buckets standing near.[4] Close by, man, or more likely, maiden, is grinding at the mill.[5] By the house-door stands the dog, so gentle that a woman may bind him.[6] Indoors, the shuttle moves to and fro in the loom.[7] We see the brewer at his mash-tub,[8] the drunkard reeling homeward, and at times falling to earth, deprived of speech and power, when he feels the effect of the mead.[9] We see the monk at his devotions,[10] or burrowing among his books.[11] We behold the "bookbinder" at his work, the scribe and illuminator at his task.[12] By the edge of the clearing we catch sight of the falcon on the wrist of the ætheling;[13] in the holt we see the stag shaking the rime from his flanks as he hears his pursuers; on the roof we behold his horns fixed as trophies of the chase.[14] And their poetry gives us glimpses also of the homelier aspects of nature—of the salmon leaping in the pool,[15] the cattle roaming the earth, of autumn with its laden fields and golden fruits, of spring with hoar-frosty lawn.[15] The birds are singing in the trees, and there, too, croaks the raven after stripping the gallows of its load.[15] But why multiply instances? These and a hundred others depict them

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1 "Rid.," 13.
2 "Rid.," 22.
3 "Rid.," 35.
4 "Rid.," 53.
5 "Rid.," 5.
6 "Rid.," 51.
7 "Rid.," 57.
8 "Rid.," 29.
9 "Rid.," 28.
10 "Rid.," 49.
11 "Rid.," 50.
12 "Rid.," 27.
13 "Rid.," 80.
14 "Rids.," 88, 93.
15 "Gnom. Ver.," 6 *et seq.*

not only as an industrious but also as an observant people, and present us with a picture of homely English life, which is not altogether dissimilar to that on an upland farm to-day.

Our next line of inquiry obviously is into the bond which bound together the various units of the individual communities. Isolation, as a rule, means close internal union, and nowhere is this "clannishness" better exemplified than here, for it was the duty of a clansman to avenge his fellow's death on the *whole clan* of his murderer, and the old poetry reaches its highest level of dramatic intensity when, in this connection, it depicts the conflict of opposite emotions—when, for example, paternal duty clashes with the duty of the avenger.[1] Their law was a *lex talionis*, "an eye for an eye," or a just equivalent, and this equivalent, or *wergyld*, as it was called, was regulated by fixed scale, even in cases of homicide, and prevented their feuds from degenerating in a mere vendetta. We have constant reference to this in their poetry, and illustration of it in the old English proverb—"Buy off the spear or bear it."

This close blood-bond is best illustrated in their attitude towards the chief, or, in later times, the king. It was for the chief the soldier fought. It was infamy of the deepest dye to desert or survive him.[2] Many a proud vaunt in the hall gives evidence of its fulfilment in the words—

"Thane-like he lay near his liege lord;"

and lines like this might well be called "historic snapshots," so clearly do they exhibit the spirit of the times. The fiercest contumely is poured on the craven.[3] The bond of the "*comitatus*," which Tacitus, with his Roman prejudices, could not understand[4] —that close compact whereby the king was the "shoulder-comrade" of his thanes—was a union which made them undivided in death as in life. Not only did the vassals esteem it an honour to die for their chief, but they sometimes attributed to him their own deeds of prowess.[5] The coward who failed in the hour of need was deprived of his landright,[3] and *ipso facto* of his freedom, for the very privilege of being a freeman involved, as an indispensable qualification, the possession of land. For this no

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[1] *cf.* "Beo.," 2438.
[2] *cf.* "Maldon," "Beo." *passim.*
[3] *cf.* "Beo.," 2864-2891.
[4] "Ger.," 13.
[5] *cf.* "Ger.," 14; "Beo.," 1968.

amount of personal property was held to be an equivalent. He might, and very often did, attach himself to a lord or patron without forfeiting his political rights, but if he failed in his duty as a warrior, he had no longer any voice in the assembly of the people. He could not even claim the right the most obscure freeman had of taking part in a debate by his applause or his more significant silence. He must wander forth on the path of exile, and herd with the wolf and the outcast. His death in life was little better than the fate of the treacherous coward and infamously vicious of an earlier day, for whom the mire of the morass and a covering of hurdle were fitting consummation:[1]—

> " . . . a hideous crew,
> Greeted of none, disfigured and forlorn—
> Cowards, who were in sloughs interr'd alive;
> And round them still the wattled hurdles hung,
> Wherewith they stamped them down, and trod them deep,
> To hide their shameful memory from men."

Another bond, less disinterested, which bound vassal to chief, was the latter's gift-giving or liberality. Throughout the whole Heroic age we see it. Now it is a sword, now a ring, now some notable treasure. Such gifts for services rendered were of everyday occurrence, as is shown by the frequent use of the terms "gift-seat," "gift-hall," "gold-giver of men," &c., and were much belauded in their poetry. Nor were the services necessarily those of war. Songcraft, too, had its rewards,[2] often perilous enough.[3] Gradually the idea of a grant of land was evolved, and, owing to its great importance as a possession, it caused the *comitatus* to be regarded as the high road to preferment. Thus out of the *comitatus* grew the idea of feudal tenure, and finally, in some degree, what we know as the Feudal System.

So much for the dual bond that bound vassal to chief. Let us next look at the chief, or king, himself. We must not be misled by the term. He was often no more than the head of a family or clan. In primitive times he discharged the duties of lawgiver, priest, and king: his hearth formed alike council chamber and altar; and dead, he was, as we shall see, an object of worship. But if much honour was given him, much was required of him. He had to be sage in council, yet active in battle; first

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1 "Ger.," 12. 2 "Widsith," *passim*. 3 *cf.* "Deor.," 40.

in war and first in peace. Epithets, too numerous to name, are showered upon him, culminating in that epithet which occurs but once in the whole range of Anglo-Saxon poetry, that *orleahtre*[1] (*i.e.*, without reproach), attached to the lordly Hrothgar, and representing their conception of the ideal king, the Bayard of primitive times, the "*chevalier sans peur et sans reproche.*" But these epithets are not our only means of arriving at an estimate of the kingship. We see him likewise discharging his duty in the midst of his assembly, deliberating when danger threatened the land, putting up prayers and offering sacrifices to avert it.[2] But gradually, in the growing complexity of their social system, this sacerdotal function became dissociated from the administrative and judicial, while continual struggles, and the consequent demand for combined action and leadership, gradually evolved something of the modern idea of the king; but we cannot read even the long topographical list in the "Traveller's Song," we cannot even glance over their charters and their laws without seeing that the Anglo-Saxon conception differed from ours in one important particular. To them the kings were kings of the *peoples* rather than of the *land;* of the *West Saxons*, not of *Wessex;* of the *Mercians*, not of *Mercia.* What land they did hold was theirs in the same private sense as that of any freeman. With these words we must leave the king; nor have we space here to trace the growth of the Assembly whereof he was the head, for to do so would be to exhibit the evolution of the English Constitution. But we cannot refrain from proudly calling attention to the fact that, amid all the vicissitudes of her history, England, even in her darkest day, has never been without some form of general assembly to voice her people's wishes. True, it may have suffered obscuration for a time, when the chains of feudal monarchy pressed heavily upon her, when despotism threatened to blight her growing life, or when she was torn by intestine feud, yet we behold it ever arising, Antæos-like, with added strength. Call it a mere Folk-moot, call it Witenagemot, call it Great Council, call it Parliament, or by any other name you will! From the forest swamps of Germany it came to her, with the beginnings of her people, and in these intervening years it has grown and fructified, and its fruit is freedom.

Let us next examine their attitude towards war and weapons.

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[1] "Beo.," 1886. [2] *cf.* "Beo.," 175-188.

Their custom of being always prepared for war has been already noticed, and we know that in their ancient councils they sat down fully armed, and applauded by brandishing their weapons.[1] When their own tribe had no war, we see them volunteering to assist other tribes. They thought it utter stupidity to acquire by the sweat of their brow what they might win by their blood.[2] They tilled fresh lands every year,[3] lest they might give up the practice of war for settled agriculture, or lest they might be tempted to increase the comfort of their homes, and thus engender effeminacy.[4] Such is, in outline, the picture we possess of "that multitude of whelps," to quote the words of Gildas, "who came forth from the lair of the barbaric lioness," but who, barbarians though they were, were destined to uprear on the ruins of Roman civilisation the beginnings of our mighty empire. And their early life was well calculated to produce a race of heroes, for by the sword they lived, by the sword they perished, and northern legend tells us how death by honourable wounds was a sure passport to the dwellings of the gods. Parents buried their children as often as the children their parents, and we who have some knowledge of their early traditions cannot wonder that war played so important a part both in their literature and in their lives. War they took delight in. Lavished upon it is found epithet upon epithet, synonym upon synonym. We behold many a lurid battle-scene lighted up by the flashing spear or javelin, or by the white streak of shaft sent hissing on its way. War entered into the whole life of these hardy Teutons, from the cradle wherein they were suckled on the sword-hilt until their death-day, when we behold the wondrous weapons flung on the funeral pyre that after the fight opened the gates of Valhalla to many a bold, fierce Viking soul, or when we see them buried with the dead chief in his funeral cairn, that he may have fitting weapon wherewith to follow on the war-trail with Odin. Like their own Grendel, they made a sport of war. Everywhere do we find the glitter of arms; in every corner lurks a blade, on every wall hangs a buckler. The very weapons are endowed with personality; the shaft with its feather-fittings *eagerly* sings from the bow; the sword *thirsts* for the foeman's blood, and *mourns*[5] because if he himself should

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[1] "Ger.," 11.
[2] "Ger.," 14.
[3] "Ger.," 16.
[4] "Cæs.," VI., 22.
[5] *cf.* "Rids.," 19, 21.

fall in the fight he has no one to *avenge* him. Pictures like these call to our mind a famous modern instance, conceived in the same spirit:—

> "Armour rusting in his halls
> On the blood of Clifford calls:—
> 'Quell the Scot,' exclaims the Lance—
> 'Bear me to the heart of France,'
> Is the longing of the Shield."

Even battle itself, *Hild*, has a personal force when she *clutches* away the warrior. Their idea of vengeance is that it shall be prompt, steady, and sure:[1] for the enemy, "stone-dead is safest;" and for the friend, "to-day for revenge and to-morrow for mourning. If you would catch the true spirit of an English fight, turn to "Byrhtnoth's Death" at Maldon, or to the "Battle of Brunanburg." The one is a tale of defeat, the other of victory; both are living pictures of English courage. Read them in the original, or turn to the works of Tennyson, and see how the old minstrelsy looks at its best when describing the grim horrors of battle:—

> "Many a carcase they left to be carrion,
> Many a livid one, many a sallow-skin—
> Left for the white-tail'd eagle to tear it, and
> Left for the horny-nibbed raven to rend it, and
> Gave to the garbaging warhawk to gorge it, and
> That gray beast, the wolf of the weald."
>
> ("Brun.," § 14.)

These are actual pictures from history, but away back in the Saga lays we find the conception of still more desperate bravery, of fierce single-handed fight against foul monster or treasure-guarding dragon, against sea-beast or mere-wife, where we see the warrior confident that the gods will assuredly help him if he battles manfully. In such scenes as these we recognise how high was their ideal of courage, and on how firm a foundation has been reared

> "The Saxon strength, the nerve of steel,
> The tireless energy of will,
> The power to do, the pride to dare."

Courage was to them the virtue of virtues, the great leveller of social distinctions. "Eorl" did not disdain to fight with "ceorl," nor did the "ceorl" always suffer defeat. Moreover, the chief

[1] *cf.* "Maldon," 256.

dismounted and fought with his followers, even as late as Hastings.[1]

As to their actual weapons, we cannot do more than merely mention linden-shield, a protection alike against enemy and elf-shot; the spear of varying name and shape, that so often was hurled from the chieftain's hand as the signal for battle; the helmet with its boar-crest, which figured in many a stubborn fight from the days of Tacitus downwards, and which in these later years has been resurrected from the opened tomb;[2] the bow, destined to become the national English weapon; the seax, final arbiter in many a fight; and, last of all, the sword, the weapon *par excellence* of Teutonic song. We must consider it ere we pass on. It is the weapon most frequently mentioned in their poetry, and most rarely found in their graves. Thus we may conclude that it was not, any more than it is to-day, for the mere rank and file. But the extreme paucity of "grave" swords is further accounted for by the fact that they were very often looked upon as heirlooms, and passed down from father to son—weapons far too precious to be buried with the dead; and in the Scandinavian tombs, where they are more frequently met with, they are often wilfully damaged.[3] What a wealth of love is lavished upon them in the Heroic poetry! Not only have they names such as Hrunting, Nægling, and the like, but they are associated with the supernatural and the divine. They are "Weyland's work," or the "work of the giants," and on the blade mystic runes are often carved, as is corroborated in a remarkable manner by the sword found at Ash, in Kent.[4] But runes, too, at times were an enemy's work to bewitch it and blunt its edge,[5] and the sorriest hour for the warrior was when his blade broke its compact and failed to "bite" the foe.

From war the natural transition is to Burial Customs, and for a proper understanding of these we must study the ceremonial presented not only by Anglo-Saxon records, but by the full body of Teutonic literature. Here the information of Tacitus is most meagre. The obsequies that had received his attention were of the simplest description:[6] the bodies of the chiefs were merely

[1] *cf.* "Maldon," 2; Freeman, "Nor. Conq.," III., 472.

[2] *e.g.*, at Benty Grange.

[3] "Du Chaillu, "Viking Age," 195.

[4] Jewitt, "Grave Mounds," 471.

[5] "Sal. Sat.," pp. 144, 5.

[6] "Ger.," 27.

burned with certain kinds of wood, the dead man's arms, and occasionally his horse, being added to the funeral pile. Thus we should have been forced to conclude that what we read both in Saxon and in Icelandic Heroic literature is mere poetic figure and imagination had we not the direct confirmatory evidence of *tumuli* or funeral cairns. We are on the border-land of religion here, for we owe these cairns and the attention given to the dead to that inborn, but often hazy, idea of a future life which has characterised all nations. It was this that caused the rude Eskimo to bury with his chief his boat and weapons, along with certain lay figures—possibly to represent his wives—to supply him with food, and to perch his tomb on some lofty headland, that even in death he might look down with delight on play of seal or flight of bird. And the case was similar in cultured Egypt, where their very history can be read from the accurate disposition of their tombs. They, too, had their boat, in which to travel to the realm of Osiris, and for them food was provided, usually in imperishable form. And by the barren sand-dunes of Sleswick existed similar customs; food was set aside from the family banquet, for the dead, who in invisible form, were believed to inhabit their funeral cairn, or to haunt the hills and forest glades around their earthly dwelling, that even in death they might cater for the good of the living.

As to the actual disposal of the dead, their poetry and their burial mounds alike testify to a dual ritual—burning and burying; and within these, two varieties—land and sea burial. Of actual sea-burial we find no trace in England, and but one instance recorded in Anglo-Saxon poetry,[1] but that instance gets all the verification possible from the more modern rite by which it was symbolised, and by means of which it had its main features preserved in the tumuli of the north. Let us enquire into these obsequies of the golden age, and see how Scyld was shipped off into the great deep. Here we have, according to Professor Earle,[2] "the best-preserved picture that time has spared us out of Teutonic heathendom." We behold the ship riding at her anchor in the haven, glistering and ready to go. The faithful retainers convey their lord's body aboard, as he himself had requested. By the mast they place him, surrounded by jewels, precious ornaments, and war weapons—a vast multitude of treasures that were to go

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[1] "Beo.," 26-52. [2] "Deeds of Beo.," p. 108.

forth with him into the flood's possession. Overhead a gold-wrought banner flutters from the mast, and they give him into ocean's keeping that he may drift far from his kinsmen's ken. What impelled them to this custom? Had they grasped, even in that age of bronze, the idea so rarely expressed of death as a voyage, the conception so admirably presented in the lines of Tennyson?—

> "Sunset and evening star,
> And one clear call for me!
> And may there be no moaning of the bar,
> When I put out to sea,
>
> "But such a tide as, moving, seems asleep,
> Too full for sound and foam,
> When that which drew from out the boundless deep
> Turns again home.
>
> "Twilight and evening bell,
> And after that the dark!
> And may there be no sadness of farewell
> When I embark:
>
> "For tho' from out our bourne of Time and Place
> The flood may bear me far,
> I hope to see my Pilot face to face
> When I have crossed the bar."

Did they think that the ship, with its dead occupant, would be divinely directed to Valhalla? Or did they desire to give an air of mystery to the resting-place of the mighty dead? Or did they wish to remove the temptation to degenerating grief? Be that as it may, we behold the ceremonial here undegenerate. A companion picture is to be found in the Icelandic burial of Balder, though here burning is conjoined with burial. A funeral pyre is raised upon the deck, the gods place the body thereon, the vessel is pushed through the sand into the sea, and, as night descends upon the smoke-wrapt craft, we behold the gods still gazing across the deep towards that fading speck of light until,

> "With a crowd of sparks the pile fell in,
> Reddening the sea around, and all was dark."

That such ritual is more than a mere myth is proved by antiquarian research among the grave mounds of the north, where ships have been found in such a position as to show that the dead chief was buried aboard and the vessel earthed over, with its bows turned seawards.

In later times, however, land-burial was substituted for the older rite. When a great chief died, a huge bale-fire was piled up on a bold headland by the sea-shore; on it were placed the chieftain's body, his weapons and equipments. Smoke and roaring blaze mounted heavenwards; then a huge tumulus was reared, and therein were deposited gold and jewels and trappings of war, and there, by the scarred and wind-swept ness, they left the warrior, that his mighty spirit might be soothed by the "funeral dirge of the ocean."[1] This mode of interment, by means of fire and the subsequent raising of a barrow, is illustrated by the two Saxon graves opened at Winsted,[2] and the habit of erecting the barrow by a lofty headland is strikingly proved by the honeycomb of graves found in the hill overlooking Folkestone.[3] Of course, the ritual varied in different places, even at the same time. For example, excavations have shown that, after the Saxons in Kent had ceased to burn their dead, the practice was still common from Norfolk to the centre of Mercia.[4]

But their poetry also alludes to burial without any pomp or ceremonial, where we see a chief's body "hidden in an earth-cave," his thanes all the while sad of face because their lord had been reserved for the dreaded "straw-bed," instead of dying in battle.[5]

The last stage of their burial customs is modern in its idea, and reveals an entirely different point of view.[6] We have here a clear distinction made between spirit and body; the latter is the mere casement, and to strew ornaments over it as it lies in its grave is but vanity, altogether unable to redeem the soul or living part from the wrath of God. They have now recognised that the body can take with it unto the unknown neither gold nor silver nor any possession,[7] but is a thing of naught, fit only for the worms. Henceforth, warlike and unwarlike shall sleep together in God's acre.

But the grave did not end all. It was the Teutonic belief that in the shadow-land the dead still continued to discharge the duties they had performed in life; and this leads us to the consideration of their Religious System and its development. Without some

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1 *cf.* Burial of Hnæf or Beowulf.

2 Jewitt, "Grave Mounds," 211.

3 Wright, "Celt, Roman, and Saxon," 469, 70.

4 De Baye, "A. S. Industrial Arts," 123.

5 *cf.* "Wanderer," 8.

6 *cf.* "Seafarer," 97.

7 "Soul to Body," 57, 58.

reference to this no sketch can have any claims to completeness, for the gradual blending of Paganism and Christianity, or the raising of Christianity on the substructure of Paganism, wrought a revolution in the life and thought of Anglo-Saxon England. Waiving for the time being any study of the Earth Worship, which was the oldest form of Nature Worship the Teutons possessed, let us consider that Ancestor Worship which lay at the very root of their early religion. This "Manes-Worship," as Tylor[1] calls it, has been one of the great formative agencies in the religion of the world. It is even in this century "the practical religion of the largest part of the human race."[2] We find it in all continents and among peoples at every stage of civilisation. Among the Hindus it has shaped the entire law of inheritance.[3] In Europe saints have been canonised by a similar principle. Among our forefathers we find it in two aspects. The first of these had its origin in that proneness to hero-worship which has ever been present in the human heart, that feeling which has led to the raising of ancestors to the rank of demi-gods. Indeed, the "real" gods, the units of the proper Teutonic theogony, like those of Greece and Rome, were merely human beings on a larger scale. In proof of this we need only refer to the death of the white god Balder, or the wounding of Ares by the Greek Tydides. It has been denied[4] that Ancestor Worship had much, if anything, to do with the "actual" gods, whose home was somewhere in the far off north, to which our heathen forefathers turned in their devotions, but, in my opinion, the more we read Teutonic literature the narrower does the border-land appear between deity and demi-god. The principle of the one is merely an extension of that of the other, though the god may have originated in a mythical being, and may not have had to pass through the chrysalis stage of ordinary humanity. The Saxons themselves hint at the recognition of this principle when they represent the gods as the ancestors of their kings. The second and homelier aspect of Ancestor Worship is the worship of the ordinary dead, who have not yet been advanced beyond the mortal stage. Here we have the pure Hindu idea of worshipping ancestors actually remembered, that idea which made every

[1] *cf.* "Primitive Culture," p. 113.

[2] Maine, "Early Law and Custom," p. 58.

[3] Maine, "Early Law and Custom," p. 53.

[4] Gummere, "Germanic Origins," p. 417.

Teuton's hearthstone an altar, and the father of the family its priest.[1] Though lost to sight, these ancestors were still, in some mysterious way, preserving their connection with the living world, and carrying on the duties that had been theirs in life. Thus the viking even in death must have his ship, the hero his horse and weapons.

These gods and demi-gods required no actual temple. River, cave, or mountain was thought worthy to be their dwelling, but the centre of their worship was the sacred grove. Thus the cult of personal divinities was closely connected with another aspect of their religion, their Forest Worship, which formed an integral part of that Nature Worship wherein they invested all the forces of nature with spirit and life; but this subject we shall reserve for separate treatment.

Such were some of the heathen doctrines with which our ancestors were saturated when they burst with overwhelming force on the shores of Britain, and, unlike the other barbarian invaders of the empire, adopted neither the Roman language nor the Roman religion, but, like a black wedge driven home by the hammer of Thor, broke asunder the religion of the Celt from the fatherly care of Rome, and established in its place the faith of Thunor and Woden, till the whirligig of time brought to the shores of England yet another wanderer from beyond the sea, who was to set up again the faith in a risen Lord, which was destined in the aftertime to be the great brother-bond of the nations. The varying fortunes of Paganism and Christianity are so vividly portrayed in their literature that we seem to see stern Penda gazing with scornful sneer on the monkish train and their trembling neophytes, who were afraid to die in their fathers' faith, which, good enough for Odin, sufficed for him. To the last he hated and despised those whom he saw not doing the works of the faith they had received, and, sincere, the stark pagan died as he had lived. But history tells us how, in the main, the Saxon mind was open to conviction, and the story of their willingness to receive the Christian faith cannot be better told than in the graphic words of the alderman of Edwin:—"So seems the life of man, O king, as a sparrow's flight through the hall when you are sitting at meat at winter-tide, with the warm fire lighted on the hearth, but the icy rainstorm without. The sparrow flies in at

[1] Gummere, "Germanic Origins," p. 356.

one door, and tarries for a moment in the light and heat of the hearth fire, and then flying forth from the other vanishes into the wintry darkness whence it came. So tarries for a moment the life of man in our sight, but what is before it, what after it, we know not. If this new teaching tell us aught certainly of these, let us follow it." More directly practical were the words and action of Coifi the priest:—"None of your people, Edwin," said he, "have worshipped the gods more busily than I, yet there are many more favoured and more fortunate. Were the gods good for anything, they would help their worshippers. Therefore let us hearken to the message of these men, and learn what their law is, and if we find it better than our own, let us serve their God and worship Him." Then, seizing a spear and mounting a stallion, both of which acts were unlawful for a priest, he rode towards the sacred grove and hurled his spear at the sacred temple. Thus priestly craft and witan accepted the king's religion.[1] But the new faith did not entirely supersede the old, as we shall presently see. They lived on together, each profiting by the other. How, then, are we to explain this ready acceptance, this mutual lending and borrowing, this gradual welding together? The best answer to the question is got from the old literature of the Northland, where the Teutonic Paganism had time to develop before it was affected by Christianity. There, in the "*Volo-Spa*," or "Sibyl's Prophecy," the "highest spiritual effort of the heathen poetry of the north," we read these words:—

"In the beginning, when naught was, there was neither sand nor sea nor the cold waves, nor was earth to be seen nor heaven above. There was a yawning chasm [chaos], but grass nowhere, ere the sons of Bor, who made the blessed earth, raised the flat ground. Then the Sun shone forth from the south on the dwelling-stones, and the fields were mantled with green herbs. The Sun knew not her inn, nor the Moon his dominion, nor the Stars their place. Then all the powers, the most high Gods, assembled to their judgment-seats and took council together, giving names to Night and the New Moons; they called Morningtide and Midday, Afternoon and Eventide, by their names, for the counting of seasons. . . . . I see, farther in the future, the mighty Doom of the blessed Gods. Brothers shall fight and slay one another, kinsfolk shall break the bonds of kindred. It shall go hard with the world. . . . The sons of Mimi are astir, the Judge is moving at the blast of the Horn of Roaring. Loud blows Heimdal, the Horn is on high. Woden talks with Mimi's head, the towering ash Ygg-drasil quivers, the aged tree groans, the Giants have broken loose.

[1] Bede, "Eccl. Hist.," Bk. II., ch. 13.

. . . The Giant Hrym comes driving from the east: high he holds his linden-shield; the monster Dragon writhes in giant fury; the Serpent lashes the waves, the Eagle screams, Pale-neb [the Vulture] tears the corpses. Nailboard [the Ship of Doom] is launched. A bark is speeding from the west: the Sons of Muspell [the World-Destroyers] are crossing the sea with Loki for steersman. All the Demons are marching with the Wolf: Byleist's brother [Loki] is in their ranks. From the south comes Giant Swart (Surtr), fire in hand, the sword of the Demon of Death shines like the sun. The granite-rocks are rending, the ravines fall in, the Dead are marching up the road of Hell, the Heavens are riven. . . . The Sun turns to darkness, Earth sinks into the deep, the bright stars vanish from out the heavens, fume and flame rage together, the lofty blaze plays against the very heavens. . . . But I behold Earth rise again with its evergreen forests out of the deep . . the fields unsown shall yield their increase. All sorrows shall be healed. . . . Balder and Hod shall dwell in Woden's mansions of bliss, in the holy places of the blessed Gods. . . . I see a hall, brighter than the sun, shingled with gold, standing on Gem-lea. The righteous shall dwell therein, and live in bliss for ever." ("Corpus Poeticum Boreale," pp. 193-201.)

These quotations show how readily the Teutons would accept the Christian creed, which presented so many possibilities of union with their own. With the destroying sword of Surtr before their eyes, they had no difficulty with the Day of Judgment; those who had heard of Loki or of Grendel would easily grasp the idea of Satan; from the fatherhood and sanctity of the chief it was but one step to that of God; the saints and apostles were but the minor deities of Asgard; the Christian feasts were but a new form of their pagan festivals; the mass to them was but heathen rune and incantation writ a little larger. In the Calendar, Woden, Tiw, Thunor, Sœtere, Freya still were honoured names. The Easter fire was retained, but Easter now had hallowed memories; and the Boar's head, sign of the ancient worship of Freya, was sanctified by Christmas day.

But if Christianity had so many points in common with, and adapted itself so much to, Paganism, wherein lay its subtle influence? A few examples will suffice to show. The Saxon recognised the close brother-bond of blood; Christianity now showed him a brotherhood not dependent on actual consanguinity, and thus upset his heathen notion that a man of alien kin was an enemy to be hated, despoiled, and, if need be, slain. The *comitatus* had taught him to appreciate vicarious suffering, but to see One lay down his life for enemies who mocked Him while He died was an idea altogether new. Moreover, their kings

could no longer be the descendants of gods, whom the new religion declared to be non-existent. The freeman who wished to carry out his feud or claim his "wergyld" found himself face to face with the fiat, "Vengeance is mine;" war was met with the stern edict, "Thou shalt not kill;" and manual labour was rendered honourable by the Carpenter of Nazareth. These were doctrines too startling to be accepted all at once, and thus the new religion was forced to temporise, to turn charms into prayers, to cover heathen spells and customs with a thin veneer of Christianity. Thus arises the dualism we so often meet with, that rude mosaic with the interstices easily seen. God and "Wyrd" are side by side, though Christian monks, with loving but laboured art, have endeavoured to present the Almighty as the controller of all fate. In spite of their efforts "Wyrd" is everywhere; she whirls all things to change;[1] she weaves the web of destiny;[2] her prestige is hardly affected by the idea of the Eternal One, whom the "Wyrds" change not.[3]

Into their homely life this same dualism enters. The countryman's land is bewitched.[4] To cure it we have a heathen spell with a Christian setting. "Erce, Erce, mother of earth," divides the honours with the Almighty. The Paternoster and Benedicite cannot hide the underlying heathenism. Again, the farmer's bees are swarming and making for the woodland.[5] In their case, too, "Earth" is all powerful, and as he throws a handful of it under his right foot, and chants his charm, they sink obediently into their hive. Another has taken a sudden pain;[6] the witch-doctor outruns both leech and priest. Another has lost his cattle;[7] he repeats a charm—Christianised—for their recovery. Thus do we find magic mixed up with Christianity by the church when it was unable to uproot superstition; and so, not merely in their national ceremonial, but even in the rude folk-customs of "unlettered hinds," the old religion lived on, coloured and modified by the new.

But there was one aspect that was little coloured and almost unchanged—their attitude towards Nature. By this we mean not the simple facts of tree and field and river, such as we have already glanced at, but the grand powers and phenomena of Nature, which entered so much into their worship, as it has

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1 "Ruin," 25.
2 *cf.* "Beo.," 2574.
3 "Gnom. Ver.," (Ex.) 1, 8, 9.
4 "Charms," 1.
5 "Charms," 2.
6 "Charms," 3.
7 "Charms," 5.

entered into that of every other primitive people. For the contemplation of Nature is the true starting-point of poetry, mythology, science, and religion. In the case of our forefathers, such was the effect of their early environment, and such the awe resulting from their Forest Cultus, that to them Nature was in the main an angry goddess, and her great forces were minor gods against which puny man could not contend. Hence wildness rugged and barren is their theme, nature drear and comfortless—the leafless tree, the icy crag, the howling storm-wind that lays the world awaste, the long roll of the wintry sea, the moorland wherein dwell the monster brood that will do them hurt, the marsh and woodland with their indwelling terrors, nicors and dragons huge and formless as the mists that breed them, the denizens of hell, the icy cold, and all the adverse forces that by night do their deeds of evil. But we cannot follow the subject further. To exhaust it means to traverse the whole range of Anglo-Saxon poetry, and to do so means to grasp, above all other things, the fact that their attitude towards Nature differs as widely from ours as may be; and that if the gulf is bridged by any modern it is by Shelley, who, even more than Wordsworth, is our poet of Nature in its grander aspects.

These, then, are a few of the characteristics of the founders of our race which their poetry has preserved; and if we have preferred to dwell upon their strength, it is because others have done full justice to their weakness. Moreover, it is their strength that we inherit, our weaknesses are our own—weaknesses incidental to our age, as theirs were incidental to their age. We do not recognise in the Teutonic Calibans of some of the ethnologists, in the caricatures of Taine or of Guizot, our Germanic ancestors. We prefer to ask those who have painted them as savages but a single remove from the brutes that perish, to remember how Rome recognised their potential greatness and thought of them as allies, how Caesar saw they were a mighty force to reckon with, how it required the genius of a Marius to save the empire at Aquae Sextiae, how a "barbarian" emperor wielded the Roman sceptre. Such men could hardly be degraded barbarians, and while—to paraphrase Heine—we are not "to seek in old Germanic forests those virtues that we miss in modern drawing-rooms," yet we must recognise that they had in them the germ of true greatness. Let us inquire rather than scoff, let us study their writings and themselves rather than accept at second hand what has been said

about them; and now that the claims of the Anglo-Saxon language are being feebly heard amid the battle-din of Classic and Scientist, let it be no longer said that, like the proverbial prophet, it is without honour in its own country. But as we inquire, let us remember that we are dealing with the child-life of a nation, and that it is difficult for us to enter into their feelings. For we have passed through the outer portals of science, we have wrested from her some of her weightiest secrets; by us the veil has been lifted from the face of Nature; by us her facts, "the stern children of a passionless reality," have been catalogued and inventoried; by us sound and light have been dissected; by us, too, the rainbow—the ancient "Bifröst, Bridge of Asar"—has been declared an unsubstantial thing, on which may no longer stand Heimdall, the watchman of the gods; by us even the thunderbolt has been reft from the mighty hand of Thor, and made a mere plaything for a scientific child. We do not, like our forefathers, stumble blindly from fact to fact, "believing where we cannot prove." We have lost their child-like haphazard, but we have lost, too, their child-like faith. We may have harnessed the mighty waters and forced them to do our bidding, but we cannot hear the mystic message of the rill, for if we know where they feared, we are too often deaf where they heard. Thus our ancestors were, and thus we are. But let us bear in mind that they planted, their successors watered, and we are gathering the increase; and it is to the results of their stern simplicity and incipient greatness that we owe the fact that England throughout the rolling ages has gone on from strength to strength, and that for her has not yet been spoken the last of these four words of eternal truth, which, concerning all things earthly, we find written with pen of iron upon the scroll of Fate--BIRTH, GROWTH, MANHOOD, DECAY.

ECONOMIC SCIENCE SECTION.

PRESIDENT'S OPENING ADDRESS.

III.—*On Indian Economics.* By GEO. HANDASYDE DICK.

[Read before the Society, 12th January, 1898.]

THE occasion of a sessional presidential address, is recognised as a suitable opportunity to call attention to any prominent point bearing upon the objects of the Society addressed. Because of this, and in view of erroneous impression and opinion existing, which tend to hamper the growing interest in and progress of economic science, I preface my address with the following extract from a somewhat ancient record—the "*Encyclopædia Metropolitana.*" It sets forth the attitude and purposes of our science. The statement is as true now as when it was written, and it accurately describes the attitude I seek in approaching the subject to come under our consideration:—

"The duty of each individual economist is clear. Employed, as he is, upon a science, in which error, or even ignorance, may be productive of such intense and such extensive mischief, he is bound, like a juryman, to give deliverance true according to the evidence, and to allow neither sympathy with indigence nor disgust at profusion or at avarice, neither reverence for existing institutions nor detestation of existing abuses, neither love of popularity nor of paradox nor of system, to deter him from stating what he believes to be the facts, or from drawing from those facts what appear to him to be the legitimate conclusions. To decide in each case how far these conclusions are to be acted upon belongs to the art of government—an art to which Political Economy is only one of many subservient sciences."

The presidential address which I had the honour to deliver to the Philosophical Society of Glasgow last session dealt with

points of Economics from a commercial aspect. It gave rise to an amount of interest in marked contrast to the obscurity of the writer, and the liberality of our Society responded by authorising its republication. I am informed that the views expressed with reference to India have been largely reprinted there, and that the paper has been republished in the United States. The paper was professedly of a diffuse character, intended to awaken fuller consideration and discussion. To-night I propose to limit observation to one branch of what was then indicated, so that it may be considered in more detail.

For brevity's sake, there has to be omitted from this paper all consideration of the economic position of the governments of the various Presidencies of India, though these governments expend revenues in amount nearly equal to one-half of the total Indian Imperial expenditure; also the wonderful system of Village Government, which has prevailed in India from the dawn of history; and the Municipal Government of the larger cities. So far as its government is concerned, our view is thus confined to the Indian Imperial problem. Thus limited, the subject is still too vast for a presidential paper, but it is not too vast to hinder the presentation of salient aspects, or to prevent the indication of prominent points upon which larger knowledge and better opinion can be sought.

There is nothing in the general attitude of the public of this country, and but little in the attitude of our press, to lead to the assurance that the electorate of Great Britain recognises that its mastership of India carries with it the final responsibility for the just administration of India. On the contrary, the manner in which the affairs of India are neglected and ignored by the House of Commons year after year, is nothing short of discreditable.

Again, amid the high pressure of thought forced upon a society such as this by many circumstances, even the prominent facts relative to India are apt to escape the general memory.

I therefore take leave prefatorily to say, that for many centuries India has been celebrated for its ancient learning and civilisation, for the wealth of its natural productions, as well as its costly and beautiful manufactures. Popularly, and in the past, India has always been associated in our minds with vast wealth.

The people of India, with some reservation regarding the inhabitants of the great cities, have been described by Markham

as "singularly temperate, chaste, honest, peaceable, singularly docile, easily governed, and patient." So far as my residence among them is a guide, I confirm that opinion. I also desire to place on record the charitable benefactions of all classes and creeds. Several native Bombay merchants could be named who have, individually, given as much for philanthropic objects out of their own pockets as the total public subscription raised in Great Britain last year for famine relief in India. Nothing I know of in this country appears to me to approach the charitable liberality of the Indian people. Suffice it to say that, in a country abounding with the poorest of the poor, there is no poor law. It is found that, in ordinary times, the benevolence of the people, who are mainly very poor themselves, voluntarily maintains all the indigent. The beautiful Scottish Orphanage in Bombay was erected by a Hindoo gentleman, and the Infirmaries, Rest-houses, Free Dispensaries, Sanitoriums, &c., which have been provided by our native fellow-subjects in India, prove a trait in native character of an exalted kind.

In one of its economic aspects, India is in a specially favourable position—a position which some would fain see established in this country—viz., all agricultural land is practically the property of the Government, and the rent paid for it (called Land Revenue) was, till recently, the largest source of revenue the Government had. Sad to say, the taxation now exceeds it.

In this place it may be noted that, prior to the British rule, the land revenue of India was collected by a system of tithes in kind—a certain proportion of the crops produced—and this is still the system in a number of native States. Under that system, if the harvest proved a failure, no claim could exist for a proportion due to the State. Under British rule, however, that ancient system has been discarded in favour of a fixed annual money payment, due and exigible whether the land yields crops or not. Under the present plan it is manifest that, with the people too poor to keep in hand one year's rental from the money proceeds of a previous year, they are, if the crop fails and when the rent comes due, forced into the clutches of the native money-lender. He is no more scrupulous in his terms than his brothers in the West. I merely state this point as important; its exhaustive discussion would occupy an undue amount of the time at our disposal.

The history of India has been intimately associated with the

British race for centuries. On the 31st December, 1600, a charter was first granted to a number of London merchants by Queen Elizabeth, under the title of "The Governor and Company of Merchants in London trading to the East Indies." In 1662 this Company had the right conferred upon it to make war and peace with the native princes. The vast powers it received and exercised during its dominance were used, not in the interests of the people of India, but were controlled by the avarice and ambition of the East India Company. This resulted in that Company acquiring for its proprietors enormous profits, as well as sovereign powers over numerous peoples and over immense districts of India. It also acquired grave discredit to itself as a government. The powers of the East India Company were largely limited in 1833, but it continued to rule up till 1857, when the Mutiny occurred. In 1858 the governing powers of the Company were taken from it by Act of Parliament, and India was absorbed under the British Crown. Queen Victoria was declared Sovereign of India. At that time this country's moral tone, and its patriotism in the grand sense, had been exalted by the terrible events of the Mutiny. On the assumption of sovereign authority by Queen Victoria, she issued a proclamation to the people of India in the nature of *A Charter of Rights.* This proclamation had universal approval in this country. No Briton to-day can read its main provisions without a sense of pride at the policy which Britain, through the act of the sovereign, declared for India.

The Queen's proclamation stated—"We hold ourselves bound to the natives of our Indian territories by the same obligations of duty which bind us to all our other subjects, and these obligations, by the blessings of Almighty God, we shall fully and conscientiously fulfil.

"In their prosperity shall be our strength, in their contentment our security, and in their gratitude our best reward. And may the God of all our Power grant to us, and to those in authority under us, strength to carry out these our wishes for the good of our people."

Thus it is that the interests of Great Britain in India have been growing for 300 years. Also, that since 1858 the British Government has been the sole paramount power in British India. The inhabitants of that vast portion of Asia have been our fellow-subjects for forty years. How far our rule has been for the

economic advancement of India, or how far it has been opposed to that advancement, is what we have now to consider.

Entering upon that consideration, it is essential to bear in mind the *State of India prior to its government being gradually absorbed* by the East India Company and by Great Britain. Before the arrival of the dominating British in India, that country had been held by numerous foreign conquerors. The Mahomedan Conquest dates from 1001, and subsequent Indian history records many changes of dynasty. Such dominance was founded mainly with the object of using the conquered, with what they possessed and as far as possible, for the material enrichment and the ambitions of the conquerors. In addition to foreign aggression, India suffered from wars between her different States —each having its individual ruler. In those times she was frequently devastated by famine and disease, as well as by wars of race, caste and creed.

Under the British Government, the foregoing and other enormous disadvantages from which the people of India suffered, have either been mitigated or entirely removed. Now, over that vast and populous continent, peace (outside of tribal difficulties beyond the frontiers), good government, and all that is included in the comprehensive phrase, "security of life and property," obtain to an extent that bears favourable comparison even with European countries the most ancient and most stable. Wars between individual States have ceased; measures for the mitigation of recurring famine have been introduced; European science has been usefully employed in arrest of disease; religious freedom has been secured; and many customs which civilisation regards as barbarous, have been removed, although others, due to custom and religion, still remain. Internal and external means of communication have been opened up; enormous irrigation works have been established; and education, up to the university standard, is freely provided; transcending probably all else, equal laws have been equally administered. Such results accomplished for 225 millions of people in British India, in addition to a vast population in native States subject to the British power, dwarf the other great achievements of Britain in her unexampled progress. These results are recognised with gratitude by all the educated classes in India, as well as with just and well-founded national pride by ourselves.

But all is not thus bright in the Indian situation, and attention must be given to the reverse side of the picture.

Perhaps it is one of the weakest points in the system of the Government of India that it is, in practically all its highest offices, carried on by officials who are not of the soil; nor likely, when their term of service is ended, to continue resident in India. Their aspirations generally are not associated with India at all, but with the mother country. I think it is reasonable to say, that in the case of the vast majority of British-born officials in India, the time for their leaving India for good and all, with their pensions earned, is eagerly longed for. Nothing is further from my thoughts than reflecting upon the covenanted civil service of India. I do not know of any body of men anywhere, more entitled to the highest esteem and respect of all earnest men everywhere, than the covenanted civil service of India. But they are human and British born, and we must recognise plain facts confirmed by everyday experience.

The Government of India has another weakness, in that its policy is subject to home influence and domination. Between what is known as the "Forward policy" and the alternative policy of "Consolidation," there is divergence of the widest. The former includes extended dominion and the rapid construction of railways and other works, at the cost or under the guarantee for the State, without much regard to the financial ability of India to bear such outlay so long as her borrowing power is unimpaired. Such a policy doubtless possesses an attraction for the higher British statesmen in India (whose offices are of a generally temporary character) which the slower and less brilliant alternative has not got. In this connection, too, it should never for a moment be overlooked, that a government by alien paid servants, whose ultimate masters are also foreigners, and, as a whole, alike negligent and ignorant, has frequently before—and in India itself on more than one occasion under the East India Company—led to the same economic results as those apparently affecting the Government of India now.

In connection with the disadvantages under which India labours, there has to be noticed the very remarkable attitude of mind of the British public towards India—an attitude which is as unreasonable as it appears to be universal. The point I emphasise is, that the British-born subjects of the Queen Empress appear seldom to recognise that their Indian-born fellow-subjects are as much, and as truly, subjects of the Queen Empress as they are themselves, and that they are entitled to equal consideration as such. The

Empress, as the embodiment of all authority in the Empire, holds herself "bound to the natives of our Indian territories by the same obligations of duty which bind us to all our other subjects." Common conversation and ordinary writing in the daily press in this country, uniformly ignores this fundamental equality. What we constantly hear and read is, that India is "held by the sword," "governed by the sword." But India is now no more held by the sword or governed by the sword than is England or Scotland, or Ireland, or Wales. British India is as much part and parcel of the British Empire as they are; she is quite as peaceful and loyal as any of these countries, and has been so for forty years. Until the mind of the British public gets to understand that Britain and India are one, tied up together in one common bundle for the common good, India, her people, and her affairs, will fail of that sympathetic appreciation of her economic difficulties and disadvantages which is so readily given to all countries within the pale of the Empire; and even to Armenians, Cretans, Greeks, *et hoc genus omne.* The people of India have not the same voice in the making of their laws as the people of Britain. They are not yet fitted for such responsibility. But their education is progressing quickly, and, as their economic knowledge advances, they will, if granted moderate and tentative opportunities for its practical application, gradually become both entitled and qualified to take large and beneficent part in making the laws under which they live, and by which, it is the desire of their fellow-subjects at home, that their country should grow alike in material prosperity and in all well-being.

I now direct attention to the *Manner in which British rule in India has been established.* The establishment has not cost the British invader a penny of money. Under the old East India Company all the revenues necessary for the Government of the country, as well as for its warlike operations, were derived from India itself. These were in addition to the enormous profits of the Company in its trading capacity, and to the gains of its officers and dependents, which, though unrecorded, we know were vast. Since India has been annexed to the British crown, the same system of payment has held good. The cost of all wars in India—conducted by its British conquerors and not by the potentates or peoples of India itself—have been borne wholly and solely by India. British soldiers, as well as British pensioners, have for many years been gathering large emoluments out of India. She has been the *El*

Dorado of the British Army. I have never seen it suggested, and indeed it would not be true, that India's soldiers have benefited out of the revenues of Britain. The world has never before seen a handful of foreigners landing on a vast continent, and in a gradual way, during a period of time extending to nearly three hundred years, conquering that continent without expenditure of its own money and with comparatively little expenditure of the lives of its home-born soldiers. Britain has done this largely by paying out of Indian revenue the more warlike races of that continent to overthrow the formerly existing rulers of the native races and their defenders—using the "pice" of the weak to buy the strength of the strong. Not only is the foregoing the case, but the soldiers and revenues of India have been contributed to British imperial interests. It is also true of the wars of India in the past, as it is true of the wars which are now taking place in the North-west Provinces, that while it is Indian blood in Indian pay that is being poured out most abundantly in Imperial service, the glory and rewards of battle are mainly reserved for British-born officers and soldiers.

How far does the system on which India has been conquered account for the known poverty of India to-day? This is a question of vast importance, but outside of parliamentary inquiry it is impossible of precise answer. It does not, however, seem unreasonable to suggest, that, so far as the conquest of India was obtained by borrowing money from abroad on Indian account for its accomplishment, to that extent at least the economic position of India is to the worse and not to the better. To charge India with the cost of conquering herself in favour of British rule, and upon that conquest to establish a government where all the principal officials, civil and military, are foreign in race and religion—who practically regulate their own emoluments as well as the emoluments of the native employés of Government—the hewers of wood and drawers of water—surely this is to set up and establish a state of things requiring the abrogation of fundamental doctrines of economics. In the Mutiny year, and the two succeeding financial years, there were deficits on the Indian Budgets aggregating over Rs.300,000,000.

After *Forty years of exclusively British Rule in India*, and our popular convictions that we had been the regenerators and saviours of that country, we were this year startled and appalled to find that, through a partial failure of the crops in India,

80,000,000 of our fellow-subjects there were threatened by a scarcity that, according to the statements of the Government, if unrelieved, might involve 40,000,000 of them in death by starvation, and 40,000,000 of them in scarcity inimical to health, and that at a time when there was sufficient food in the country to feed the whole population at a cost of less than a penny per head per day of our money. There has also been an outbreak in India of the plague known as Black Death. In view of former knowledge and existing experience, this plague cannot be disassociated from the poverty of the people. For its arrest and extirpation it appears to be more abundant diet, and not vaccination, that is necessary.

In recent months we have had what have been called seditious riots in the Bengal and Madras Presidencies, seditious writing in other places, and the assassination of two British officers in Poona. These events gave rise to a measure of unrest and alarm among the European population in India, and to ourselves at home, which their gravity did not justify. In view of what was known in India and was feared in this country as to the economic position, the alarm was more explainable. Another calamity to India, but beyond our control, and for which we were therefore not answerable, although it has been injurious to a number of people in India, was the earthquake that lately visited extensive districts.

According to the *1891 Census of British India*, which is exclusive of the inhabitants of native States under British suzerainty, the population was 221,173,000, and adding to these figures one per cent. per annum, or 6 per cent. in all, for its estimated increase up to this date, we get with close approximation 224,443,000 as the population to-day.

What has been said in the foregoing is intended as introductory, to show historic environment affecting the existing economic position of the Government of India, and the economic position of its people to-day.

Passing from the introductory, we naturally come to consider first the financial position of the Government of India in its varied aspects. It is impossible to present these aspects in a simple form. The first difficulty is, that the accounts of what may be called the Home Office are kept in sterling money, while the accounts in India are kept in rupees, and there is no fixed relation between rupees and pounds; they vary to one another almost daily. Again, the Budget estimates, prepared in Calcutta, are in their relation

to home charges, and partially, of the nature of cross-entries, or showing only one side of an account. Thus in the Budget estimates of 1897-8 (blue book, 193, pages 13, 58, 60) we find, "Expenditure in India—Railways, Rs. 13,752,000;" "Revenues of India—Railways, Rs.20,682,100." This would lead to the conclusion that railways in India showed a gain of Rs.6,930,100 to the State. But that would be quite erroneous. By reference to a table at page 29 of the blue book, C 8136, "Railways in India, 1895-6," we find the loss to the State upon railways amounts, for the period from 1858 to 1896, to the enormous sum of Rs.529,274,960. To get the result of running the lines, we have to turn to the Home Accounts, and find the charge for interest on the cost of the lines, together with the loss by exchange in remitting the same from Calcutta to London. Another difficulty in the way of a simple statement is that the information available in the many blue books is made up for different periods and at different dates.

In the figures which follow, the sign Rx. is conventionally, and when not otherwise stated, taken to be the equivalent of the sign £. Thus Rx.100,000 is conventionally taken as £100,000.

The first point we consider is what may be called the *National Balance Sheet of the Government of India.* It is given at page 23 of the blue book, C 8169, "East India Accounts and Estimates, 1896-97." There the assets and liabilities of the Government of India, at 31st March, 1896, are given as—

IN INDIA.

Liabilities.		*Assets.*	
Debt, - -	Rx. 103,782,000	Railways, - -	Rx.89,331,000
Other Obligations,	19,205,000	Irrigation Works,	31,109,000
Assets over Liabilities, - - -	25,453,000	Loans to Corporations, &c., -	11,499,000
		Cash Balance, -	16,501,000
	Rx. 148,440,000		Rx. 148,440,000

IN ENGLAND.

Liabilities.		*Assets.*	
Debt, - - -	£115,904,000	Railways purchased, -	£59,236,000
		Advances to Railway Companies, - -	5,608,000
		Cash Balance, - -	3,795,000
		Liabilities over Assets,	47,265,000
	£115,904,000		£115,904,000

Calculating the excess of assets in India of Rx.25,453,000 at 1s. 3½d. per rupee exchange, gives £16,438,395. Deducting this amount from the excess of liabilities over assets in England—viz., £47,265,000—we find that, as a going concern, India is "behind the world" by £30,826,000, after taking as good assets all the cost of State railways, irrigation works, loans to corporations, and advances to railway companies. It will be shown later that, owing to losses from exchange, the railways at present result in loss to the Government and not in profit. Therefore, viewed commercially, these railways are not a good asset as things stand. They are, in fact, a liability. In the balance sheet they represent £64,844,000, and Rx.89,331,000 at 1s. 3½d. equal £57,692,937; together, £122,536,937. This is the enormously preponderating sum of what professes to be, but is not, the assets of the Government of India. Such accounting recalls the balance sheets of the City of Glasgow Bank. In fact, in the commercial view, India is, as a going concern, behind the world by £153,362,937, and, in addition, should be debited with the capitalised value of what she has to pay yearly for railway gold debt in excess of what her railways return when exchanged into gold.

It has further to be noted that the tendency of the Indian Government is to increase its expenditure in many directions, and that its avowed policy is to increase it upon railways. (Blue book, 193, page 170.) For this expenditure further gold debt must be incurred—rupee loans are impracticable at present for several reasons—and, if the rupee falls further in value, this will accentuate the position in which India at present finds herself financially.

Pursuing our enquiry, we now consider the *National Debt of India.* (Explanatory memo. by Secretary of State for India, blue book, C8169, page 23.) Reduced to a sterling valuation, at 1s. 3½d. per rupee, the amount owing in India at 31st March, 1896, was

Rx.122,987,000, - - - - - - - =	£79,429,104
and the amount owing in England was - - -	115,904,000
Together, - -	£195,333,104

The total debt of India in 1870 was £108,000,000 (Mulhall Dictionary of Statistics, page 134). In 1882 it had risen to £156,000,000, and in 1896 stood as above. This shows the average increase of India's debt to be at the rate of 3·2 million pounds

sterling per annum over the past 27 years, or a total for the 27 years of £87,000,000.

Dividing the above debt of £195,333,104, at 1s. 3½d. per rupee = Rx.302,451,257, among the population of India, the amount per head—viz., Rs.13/10/—may strike the people of this country at first sight as unimportant. But all things are relative, and we must view India's debt having regard to the poverty of her people. This will be referred to later.

Now turn to the *Revenue and Expenditure of British India.* The following figures are taken from a return, of date 5th March, 1897, entitled "Return of the Net Income and Expenditure of British India, under certain specified heads, for the eleven years from 1885-6 to 1895-6" (Return to the House of Commons, No. 110, 4th March, 1897, page 7).

The *Revenues of India* are comprised under four heads, as detailed below, viz.:—

	1885-6.	1895-6.
Land Revenue, &c.—Net Receipts,	Rx.23,407,741	Rx.27,472,381
Opium, ,, ,,	5,884,325	5,049,894
Taxation, ,, ,,	18,489,874	29,627,357
Miscellaneous, ,, ,,	405,461	392,453
Excess of Expenditure over Income,	2,801,726	...
	Rx.48,187,401	Rx.62,542,085

These figures show that the increase of revenue from the two principal sources in eleven years is—

Land Revenue Increase,	Rx.4,064,640
Taxation ,,	11,137,483
Total,	Rx.15,202,123

That is an increase in the two great items of revenue of 36 per cent. in eleven years, but, deducting 6 per cent. for increase of population, leaves an actual increase of 30 per cent. per head! It is to be noted that this enormous increase of taxation over eleven years falls upon the people of India directly and wholly, and has no compensating money return that is appreciable by them.

Turning to *Expenditure of India*, we find, from the same authority (Return 110, pages 12 and 17), that for—

1885-6 it totalled - - - - - -	Rx.50,989,127
1895-6 ,, - - - - - - - -	61,008,087
Increase, - -	Rx.10,018,960

being an increase roughly of 20 per cent., less 6 per cent. for increase of population, equal to a net increase of 14 per cent. per head in eleven years.

In connection with the foregoing, it is to be observed that in 1887-8 the amount charged for *Famine Relief and Insurance* was but Rx.376,607, while in 1881-2 the amount charged was Rx.1,567,886. (Blue book, C 8169, page 12.) From this it is not unreasonable to conclude, that the charge has been fixed more by the exigencies of the Indian Government in adjusting its accounts, than by the necessities of the case and the policy laid down. For the past sixteen years the policy required that £24,000,000 should have been allocated to famine relief. Much less than that sum has been charged in the accounts, as follows:—

Famine Relief, - - - - - - - - - -	Rx.387,863
Construction of Protective Irrigation Works, - - -	1,865,724
Construction of Protective Railways, viz., charged under	
Famine Relief and Insurance, - - - - - -	7,029,364
Charged under Railway Revenue Account, - - -	4,033,934
Reduction or Avoidance of Debt, - - - - - -	5,327,299
Total, - - - - -	Rx.18,644,184

I was in India at the time this famine relief policy was inaugurated, and I say that no one then anticipated any such disposal of the fund as this. Indeed, it was understood that the policy was adopted with the express purpose of creating a special fund which could not be thus diverted. At that time the Viceroy of India, Lord Lytton, said—"The sole justification for the

increased taxation which has just been imposed upon the people of India for the purpose of insuring this country against the worst calamities of future famine, so far as an insurance can now be practically provided, is the pledge we have given that a sum of not less than a million and a-half sterling—which exceeds the amount of the additional contributions obtained from the people for this purpose—should be annually applied to it. We have explained to the people of this country that additional revenue by the new taxes is required, not for general purposes, but for the construction of a particular class of public works, and we have pledged ourselves not to spend one rupee of the special resources thus created upon works of a different character."

To charge losses of railway revenue and reduction or avoidance of debt, to a special famine relief account, seem flagrant instances of unjustifiable accounting and unjustifiable practices.

You will observe that the figures I have been putting before you all refer to years prior to the Indian financial year, which expires on the 31st March proximo.

We will now consider the *Financial position and prospects of India at the present time.*

The Budget estimate for 1896-7, is given in an explanatory Memorandum by the Secretary of State for India (C 8169, page 8). It states the estimated net revenue, *i.e.*, less charges of collecting,

at - - - - - - - - -	Rx.61,053,200
Estimated net expenditure, - - - -	60,590,100
Estimated surplus, - -	Rx.463,100

The foregoing has been arrived at after many important allowances *pro* and *con*, in comparison with the revised estimate of 1895-6. These cannot be entered upon here further than to point out that the considerable revenue derived from opium is a declining sum, which, under the disturbance of the exchanges between India and China, may soon reach the vanishing point.

From blue book, 193, page 7, however, the "revised estimates" (which I take to mean the "actuals," as ascertained) work out to a deficit of Rx.1,986,900. This is due mainly to expenditure and loss arising from the famine. Thus famine relief, estimated at Rx.75,000, actually amounts to Rx.1,876,200. Land revenue

comes short by Rx.2,394,100, and there is a fall in railway revenue of Rx.1,423,200. These falls are all attributed to the famine, and total no less than Rx.5,693,500. They are partially counterbalanced by a fortunate gain in exchange of £1,459,500, and by other economies. Here we have no less than four items of the Budget estimates proving in error by sums ranging from Rx.1,423,200 to Rx.2,394,100. Nothing could well illustrate better the parlous unreliability of the finances of the Indian Government.

Turning to the financial position and prospects of India for the current financial year (*i.e.*, 1st April, 1897, to 31st March, 1898). The Budget, as estimated (blue book, 193, page 12), works out to a deficit of Rx.2,464,000. Doubtless these estimates were well founded, according to the information then available. It remains to be seen whether this was so or not. One thing, however, is plain; no provision has been made for the enormous military expenditure, actual and prospective, on the north-west frontiers.

What the extraordinary expenditure for the year 1897-8 will finally amount to I have no means of stating with authority in its support. That it will be very great cannot be questioned. An indication of the seriousness of the position is to be found in the fact that from the 1st September to the 15th December of this year the sale of Council Bills had to be stopped. Last year the sale of these bills for the same period amounted to Rx.5,607,896. A further indication is that the following borrowings by the Indian Government have been made, viz.:—

In London, 2½ per cent. Stock placed, - -	May,	£3,500,000
,, Treasury Bills issued in - -	July,	1,000,000
,, ,, ,, -	September,	2,500,000
,, ,, ,, -	November,	2,500,000
Sterling Borrowings, - - -		£9,500,000
In India, Rupee Loan for Rx.4,000,000 at 1s. 3½d. per rupee	=	2,583,333
Total Borrowings this year, -		£12,083,333

Further borrowing is anticipated. The sums borrowed in gold will, of course, have to be repaid in gold, and they will bear

interest in gold. At the exchange of 1s. 3½d. per rupee, the capital borrowed represents Rx.18,709,677 as one year's borrowing (no doubt a very exceptional year), in comparison with a revenue levied to a dangerous point, but estimated to produce only Rs.61,053,200, and a surplus over expenditure of but Rx.463,100. To this financial position has to be added the fact that, on the 18th December of last year, by the issue of Government promissory notes in India, Rx.2,000,000 were set free from the currency reserve. It is generally believed that Indian taxation cannot be further increased—that any attempt to increase it would not result in gain to the revenue. Therefore the financial position indicated by the foregoing must be a cause of deep anxiety.

Rightly to comprehend the position, we must now consider *The Poverty of India,* and the total unfitness of its people to support any increase in the revenues raised by the Government from the people.

Different estimates that I have seen, place the annual average income of the people of India between a maximum of Rs.27 and a minimum of Rs.20 per head. Taking these figures at 1s. 3½d. exchange, we find the maximum in our money to be £1 14s. 10½d., and the minimum £1 5s. per annum. So far as I am aware, there is no such abject poverty as this in any other country which has a civilised government, and reckons by money and not by barter. It must not be overlooked that this is the average income. Some inhabitants, especially Europeans, have very much larger incomes than this; therefore there must be a larger number possessing smaller incomes. Accuracy in this estimate is, of course, impossible, but the larger figure has passed the review of Lords Lawrence and Mayo. Sir E. Baring, as Finance Minister of India in 1882, said that, though he was not prepared to pledge himself to the absolute accuracy of a calculation of this sort, it was sufficiently accurate to justify the conclusion that the tax-paying community was exceedingly poor. In comparison with it, he pointed out that in England the average income per head was then £33 (recently it has been stated at £42); in France, £23. The average annual income per head, as previously stated, was for average years. But the past has been much below an average year, and for it, possibly, the annual average income might be taken as low as about 20s., or as high as about 30s., of our money per head.

The average incomes for countries is arrived at upon a summation of the total value of their productions, showing in gross all that they have of a total product from all sources. When we roughly consider how vastly in excess of Rs.27 per annum are the payments for European service in India—say, from the Viceroy with Rs.240,000 per annum, to the humblest European soldier, and all the various classes of Europeans which lie between—some broad conception can be had, not only of the expenses of government by Europeans, but also of how the natives, who are alike supported out of the produce of the country, are likely to regard the riches of their alien governors in contrast with their own abject poverty. They are born of the soil, and we are but dominating fellow-subjects of the same Empress. Such dominance can only be justified by its advantages to the dominated.

Much has been written of *The Wealth of India in the past*, but in an inexact way. Adam Smith records that the superabundance of food possessed by the rich there enabled them to purchase large quantities of the precious metals and precious stones, and the consequent importation of these into India. The more or less reliable data as to the "loot" secured by her conquerors, by the East India Company and other adventurers, and the tangible proofs still existing in notable and wonderful buildings erected in India in the past, give evidence, which cannot be overlooked, of the truth, in one form at least, of the aggregate wealth of the country. We know of, but cannot particularise, the former hoarded wealth of India in bullion and precious stones, and how that old method of preserving accumulated wealth has been handed down to the present day even among the poorest of the people. Akbars' wonderful tomb at Futtipore-Sikri still exists. It had the Kooh-i-noor diamond for an ornament, and the precious stones inlaid in tomb and temple testify to great riches. The "Indian Nabob" and "the wealth of India" have been household words with us for generations.

If this was the economic position of the country during the time when it was largely possessed by what we regard, and, I think rightly regard, not only as alien but as barbaric rule, also during the rule of the East India Company, and during British rule up till recently, the question faces us—why is it that, after over 240 years of rule largely British, and 40 years of rule wholly British, the economic position of India is such at the present day as the figures I have previously given indicate? This

is a very vast and vital question. It is one which I have never seen put forward before. I state it now in the hope that its statement may lead to earnest and exhaustive inquiry into it by Parliament. Also that it may lead the scientists, as well as the electorate, of this country to consider and find the answer. It ought to be known whether financially India is advancing or retrograding under British rule. It ought to be known whether or not the Indian Government is approaching bankruptcy, and whether or not the people of India have already arrived at a position, in the instance of millions of them, under subsistence point. So far as I am aware, none of these things are authoritatively known. What I have put forward are only indications of what may be the answer, but they are indications only, and not scientific answers.

It is with vast diffidence that I venture to mention some of the thoughts in my own mind, in explanation of what I fear is the terrible and increasing poverty of the people of India, and the dangerous financial position of its Government.

It has been said by a Parsee gentleman, who for many years past has devoted himself to making plain the inequities affecting our great dependency, that, "without any intention or wish, and with every desire for the good of India, England has, in reality, been the most disastrous and destructive foreign invader of India; and, under present lines, unceasingly and every day continues to be so."

What can lend support to such wholesale and sweeping condemnation by a native gentleman enthusiastically loyal to Britain, who frankly recognises Britain's noble work there, and is so permeated by British education that any departure from the common lines of British thought must be antagonistic to all he has learned?

Seeking an explanation of this, we must consider the question from the native point of view.

The educated, wealthy, and influential among our fellow-subjects in India see eye to eye with us as to the blessings British rule has conferred upon the people of British India, and they dread—probably even more than we do—any such conception as its being overthrown. But we do not see eye to eye with them as to the disadvantages to which the people of India are exposed by the same rule. Thus, the leaders of Indian thought recognise the advantages which the Universities set up in India have conferred

upon those Indian gentlemen, and there are thousands of them, who avail themselves of university teaching. These leaders point out that this education fits Indian gentlemen for the higher duties of life—as in the service of the State—that the Government hardly avails itself of these cheaper services at all; but, largely disregarding the Queen's proclamation of 1858, continues to crowd the Indian services, both civil and military, with highly-paid European officials. Native gentlemen point out that these British officials, while drawing their pay and pensions from India's revenues, spend large portions of their emoluments, not in India at all, but in England. It is maintained, and can hardly be questioned, that this system tends most seriously to the impoverishment of India; and also, in a degree, to the enrichment of the mother country. British officers and soldiers in India are now receiving special increased pay to the gross amount of about £2,000,000 per annum, to partially countervail the decreased exchange value of the rupee in Britain. It does not appear, however, to have been acknowledged by Government or its officials, either in India or at home, that prices in Britain have experienced an enormous fall —a fall of 40 per cent. on wholesale prices—and that the emoluments of Government servants have not in any case been adjusted to this fall.

The whole of the foregoing is a serious grievance in the case of qualified Indian gentlemen, who cannot find employment in that sphere for which their education qualifies them. It is also a national grievance in the aspect of European emoluments being so largely disbursed in England.

The system must mean an economic disadvantage to India of many millions per annum, but of which no record is kept. In this connection let us look at what is called the "*Home Accounts of the Government of India.*" As estimated for the year 1st April, 1896, to 31st March, 1897, they are given in a statement presented to the House of Commons, under date 13th May, 1897 (No. 311, page 45, *et seq.*). I will not give you the lengthened summary of these payments, but I notice the principal of them:—

Interest on Debt (excluding that charged to Railways) on Loans contracted in England, ...	£2,260,653
Interest on Railways, ...	1,192,272
Superannuation, Annuities, Pensions, and Allowances, ...	1,874,519
Railway Revenue Account, ...	5,790,567

Army (Effective), ...	£1,844,748
Army (Non-effective)—Retired Officers for Pay and Pensions,	2,368,852

The foregoing, with other charges, give a total expenditure at home of £15,804,495, exclusive of expenditure on capital account for railways and irrigation works.

The strain upon India which is represented by this annual withdrawal of her capital to be disbursed in another country must be a dominating disadvantage, alike to the Government of India and her people.

Of other economic facts making against the financial position of the Indian Government, that which overshadows all others, at the present time, is, no doubt, the fall in the *Exchange between India and Great Britain*, and—but in much smaller degree—the rise in the exchange between India and silver-using countries.

In connection with this exchange question, it is useful to recall that Britain adopted the single gold standard in 1816. From Akbars' time, and up till 1837, silver and gold were, and had always been, money in India. In that year, however, an Indian law was passed making silver the only money and standard of value for British India. The reasons—I think them mistaken reasons—that led to setting up gold monometallism in Britain we are familiar with, but I do not know any reason why, twenty years thereafter, silver monometallism should have been set up in India. In 1851 Holland and Belgium demonitised gold, fearing its plethora. England, for the same reason doubtless, but later, endeavoured to reintroduce bimetallism into India. It was enacted that the British and Australian sovereign should be legal tender, and the coinage of Indian gold pieces of the value of Rs.10 each was begun in India. But the movement failed. Gold coin was not specially desired, and there was practically no gold coin in India sufficient to maintain the exchange of gold for silver on demand. Indeed, the attempt to introduce gold into India was regarded as an effort by the British Home Government to strengthen what was then feared was depreciating gold. India is bimetallic now by law, but at an inoperative ratio, as gold commands a much higher value in silver than silver now does in gold.

Regarding Exchange, a most interesting table is given in a blue book, C 8169, page 13. Without giving all the figures, I point out that—

In 1881-2 the Nett Sterling Expenditure of India was - - - - -	£14,029,700	
And the Loss by Exchange, - - -		Rx.2,985,500
In 1894-5 the Nett Sterling Expenditure having risen to - - - - -	15,504,000	
The Loss by Exchange (in which was included payment and compensation to Soldiers and Officers on account of the fall in Exchange), was - - - -		14,615,300
That is, while the Sterling Expenditure had increased but - - - - -	£1,474,300	
The actual Annual Loss to India, due to Exchange, had increased by per annum,		Rx.11,629,800

In the last five years given in the statement, the total exchange loss to the Indian Government on its sterling expenditure, was no less than Rx.63,190,900—that is an average of Rx.12,638,150 per annum !!

But that is not all. The railway revenue of India gave, in India (C 8136, page 29), a return in rupees of from $5\frac{1}{2}$ to over $5\frac{3}{4}$ per cent. on the capital cost of these railways; but the expense of paying in England the interest on gold borrowed there for railway construction is so heavy that the result of the railway revenue account is a burden on the Government of an actual loss, which amounted in

1895-6 to - - - - - -	Rx.1,783,700

The total exchange loss in railway account is given, as for—

1894-5, - - - - -	4,774,565
1895-6, - - - - -	4,333,700
1896-7, - - - - -	4,303,100

While these railways now represent a serious annual loss to India, the gold capitalists in England who lent money for their construction continue to receive their full gold interest upon the outlay. Thus India is impoverished from the fact that all the profits arising upon her railways is absorbed to pay the interest due to British lenders upon the money borrowed to construct them. But more than that, owing to the fall in exchange, the gold interest also absorbs a large sum over and above all the railway gains. Of course, the enormous appreciation of gold gives the

holders of Indian gold debts an advantage which, at the time the loans were contracted, was neither foreseen nor intended by either the lenders or the borrowers. Equity calls for readjustment here, and the necessities of the case must apparently, under present circumstances, sooner or later, compel readjustment or repudiation.

In 1873 some person or persons unknown obtained, by a trick played upon the people, Government, and President of the United States of America, the closing of the United States Mints to silver. It is in that action, with what has flowed from it since, is to be found the main cause of the financial position of the Government of India to-day. Clearly, had India's par of exchange with Britain been maintained as it was — other circumstances being equal—the Government of India would to-day be in a strong financial position, and the people would not be exploited below sustenance point, as very many at present, I fear, undoubtedly are.

For nearly twenty years, and up till a few weeks ago, the Government of India sought the rehabilitation of silver money for the world in the interests of India. To all these appeals the British Government at home turned a deaf ear, and, on one pretext or another, succeeded in nullifying the efforts made by foreign nations and by practically all scientific opinion in Britain, in this direction. The British Government at home and the Government of the Viceroy in India were in this matter, and till recently, at wide variance. In the month of March, 1896, however, the British Government, as represented by the unanimous vote of the House of Commons, by the official statements of the Chancellor of the Exchequer and the First Lord of the Treasury on behalf of the British Government, assumed a new attitude. It invited other nations to approach Britain for the purpose of rehabilitating silver as money, and made distinct promises of what it was prepared to do in the matter. America responded to the invitation, and sent special envoys to Europe with regard to it. The French Government warmly seconded the approach, and it was understood that the Emperor of Germany also approved. Thus all seemed in a fair way to the discussion, and possible settlement of the question. A few weeks ago, however, the Viceroy's Government made a *volte face* in a despatch, the foolishness of which, in view of the interests of India, cannot be fully explained here. To seek a gold standard, which necessarily requires gold for its establishment, by a country having its last

estimated annual surplus on balance of trade but Rx.216,000 (C 8169, page 21), and that has large foreign debt, as well as large foreign payments to liquidate in gold out of its silver revenues, that has also a vast silver currency in circulation at much over its bullion value, as well as hoards of bullion silver in the hands of its people, appears a chimera of the brain indicative of total unacquaintance with the science of money and with recent monetary history. If, and when, the Argentaurum Laboratory of America succeeds in the transmutation of silver into gold, it may then be possible to establish a universal gold standard and gold currency for the world and for India.

But, stranger still, the British Government at home no sooner received the above despatch than it closed negotiations with America and France, and did that with very scant courtesy. Thus it also made a *volte face*, sacrificing its imperial policy, adopted so late as March last. Thus from overruling the Government of India, the British Government appeared to be overruled by that Government.

These changes of policy by the Government of Great Britain and the Government of India, made within a few months, call for explanation and inquiry. This inquiry appears to be specially called for in view of the attitude of the small, but very influential, class that appears to dominate the British Government in this matter. Meantime the result of these changes has been to confirm the dangerous financial position more firmly than ever upon the Government of India, and upon the poverty-stricken subjects of that rule. In the ordinary course of events, this may ultimately reach either the innocent British taxpayer, or reach the holders of India's appreciated gold debt. Equity appears to point to the latter solution. It is the solution that has been forced upon other debtor countries, upon Australian banks, and kindred institutions. A third alternative is to allow the poorest of the Indian people to die of starvation while the product of their country, that should be used for their support, is exported to pay the interest upon what has become the unjust debt of their Government. That is an aspect of the question that has not had due consideration in the past. Were it fully understood in this country, it might arouse public indignation to a righteous, perhaps to a dangerous, point. We are still without information as to the famine and plague deaths in India. The economic position of India is only one aspect of the evils that have disordered all civilised countries

since the beginning of the new monetary policy for the world in 1873.

We all know that, on the Report of a Commission which examined witnesses, the *Indian Mints were closed* to silver on 26th June, 1893. But the Commission was a farce—a trial after verdict. There was not a single witness who approved of the course adopted.

Here was probably the greatest blunder against India ever perpetrated by responsible statesmen. Its effects on the trade of India are destructive, because it has, by law, made India's money uncertain and varying in international value almost daily, and has made it artificially scarce. Its scarcity enhances the loanable value of money to rates almost prohibitive of commerce at the export season. It encourages forgery. It has deprived India of a par of exchange with every other nation of the world, and so has upset her business with China, Japan, the Straits, and all countries in the East, and has not given her a par of exchange with gold in the West. It has given India an inflated and artificial currency, having its national value in Indian law, and which, while passing by law at far over its bullion value in India, is useless for international monetary payments at much over one half of its face value. The final point I mention in this connection is, that for national payment it has brought the value of hoarded silver bullion and ornaments in the hands of the holders to a discount of, say, 30 per cent. less than the coined silver. Thus it has seriously disadvantaged every individual in India—preventing the famine-stricken availing of their savings to their full value for the purchase of food.

To anyone who knows India and the terrible poverty of its people, the resulting jealousy with which the Indian people regard anything which injures or deprives them of their money—even to a trifle which the humblest in this country would hardly regard—is an economic fact readily comprehended. Again, the contentment of the people of India under foreign dominion is readily explainable by long centuries of similar experiences, and by their faith in the justice of the British Government. Then I ask you to consider what must be the effect of closing the Indian Mints upon the great mass of the people of India as regards their faith in British rule? It is a notorious fact that the people of India, not using banks or investments, as with us, and trusting the British Government, have hoarded their means in silver orna-

ments, relying in their time of need to recoin these ornaments into money again. Now they find they cannot be so coined; that the Mints are shut against them; and that their hoards, reduced from potential money to an ordinary commodity, are only saleable and value for about two-thirds of the Government coin of which they are composed. Their ultimate value cannot be conjectured. The loss to the people of India on these accounts cannot be reckoned, but it may be guessed at many millions sterling. Under their disadvantages the people of India have remained loyal and true to us. It remains to be seen, when they comprehend this awful wrong done to them, how they will regard us and our rule. It is, probably, an economic strain to which wiser statesmanship would not have exposed them.

It would be absurd to suppose that the people of India understand the subtle causes for the depreciation of their money and the transference of their wealth. But several native Indian economists now know it. Such knowledge is likely to spread very quickly. Influential and loyal gentlemen of India are writing upon the question in the home magazines; but Professor Ghose expresses his fear to do so in the vernacular press of India.

Summing up points in the economic position of India, it is a matter of fact that her people are under a government which they are helpless to guide or influence, and must obey. From what has been adduced in this paper, it seems reasonable to say—

(1) That India has been exploited by her conquerors to the sustenance point and below it.

(2) That recent governmental action has been suborned to the gold capitalists of this country—

- (*a*) By closing the Indian Mints.
- (*b*) By, for the second time, inviting the great nations to make proposals for currency reform, and treating the proposals made with scant courtesy.

(3) That in her National Balance account India is very seriously behind the world.

(4) That her Revenue from taxing her people has very seriously increased in recent years, and cannot be further added to, and that her present Expenditure must enormously exceed her present revenue.

(5) That India's National Debt has grown, and is growing, in an alarming manner.

(6) That in so far as India's Debt has been borrowed in gold, its incidence has about doubled in the material wealth necessary to pay the annual interest upon it, and in the wealth to be given for its final redemption.

(7) That India's money is artificial and not automatic; and that it is divorced and separate from every other money in the world, so injuring India's foreign trade, as well as subjecting her to enormous loss otherwise.

If what is said in this paper are economic facts, fairly and justly, though but generally and imperfectly stated, the deduction appears to be that, even favoured with the abundant harvest of which there is prospect this year, and under normal circumstances for succeeding years, India stands in a position which may readily, if not certainly, become worse by the mere efflux of time, and is not likely to be improved thereby. The action of alien Governments may make for her prosperity if, by alteration of their currency laws, they advance the international value of India's money, or they may injure her by the reverse act. Again, internal circumstances, of which indication was given in an earlier part of this paper in referring to Bengal, Madras, and Poona, may plunge India's Government and people alike in financial chaos. In such circumstances the British Empire would receive unspeakable injury.

Finally, and to correct a very common misapprehension, let it be pointed out that, while the Government of India is apparently entitled to all credit for the wisdom displayed in dealing with the famine in that country, it must not be overlooked that the funds for that purpose have all been borrowed by, and have to be repaid by, India. This of course, is not true of the million pounds given by individuals in this country to the famine fund. The total of that subscription represents but 3d. per head to those who were actually starving in India, and when regarded in the light of the fact that India is now sending Britain, in payment of interest on her gold debt, nearly double the actual wealth in commodities which was intended by borrower and lender, the British subscriptions must be viewed rather as proof of parsimony and regardlessness than of large-hearted helpfulness and sympathy to our distressed fellow subjects.

It is for the British Parliament and for economists to seek out the facts of the economic position of India. Something may result

from the enquiry now going on, but its constitution qualifies the hopes regarding it. It is for statesmen and governors to find the remedy for removable evils that may exist; and it is for the electorate of this country—which we all thankfully recognise as honest and just according to its knowledge—to see that statesmen and rulers do their duty to our fellow-subjects in India in a spirit of fairness and equity. If this paper is helpful to these ends, it will fulfil its purpose.

IV.—*A Contribution to the Chemistry of Coal, with special reference to the Coals of the Clyde Basin.* By W. Carrick Anderson, M.A., B.Sc., Assistant to the Professor of Chemistry, Glasgow University.

[Read before the Society, 15th December, 1897.]

Considering the advance that has been made during the last thirty years in the technical treatment of coal and the products of its destructive distillation, it appears somewhat remarkable that even at the present time so little should be known regarding the chemical nature of the bodies that go to constitute it. Apart from the value of coal itself as a fuel and as a reducing agent, its decomposition at more or less elevated temperatures gives rise to almost innumerable derivatives, and the subsequent treatment of these has in turn become the field of operation of extensive chemical industries. Many of the latter, although for the most part they date no further back than a single generation, have been, and are, among the most fruitful and profitable fields of chemical technology.

But it is obvious that if such an important subject of investigation as the mother substances of the coal tar products has remained so long unelucidated, there must be some special reason to account for it. Such an explanation, and one more than adequate, is undoubtedly to be found in the extreme difficulty of gaining a footing from which to attack the problem, by reason of the insolubility of the great bulk of the constituent bodies in the ordinary chemical solvents and reagents.

Hence it has been the practice of most of those who have investigated the chemical nature of coal to seek enlightenment

rather by way of the products of decomposition than by attempts to separate distinct chemical compounds from the naturally occurring substance. Even by such methods, it must be admitted, comparatively little information has been gained, and nothing that can be viewed in the light of conclusive evidence as to the fundamental structure of the bodies in question. Yet it is safe to say that no complete and satisfactory solution of the great industrial problems of coal distillation and coke-making can be hoped for, until some knowledge has been acquired regarding the nature of the substances which go to form the bulk of the class of minerals known collectively as coal. Only then can it be expected that the—even with all modern improvements—still excessive waste of the valuable nitrogenous constituent will come to an end,* and that the manufacture of coke, a manufacture daily increasing in importance, but at present one of the most unscientific chemical industries of the world, can be put on a thoroughly satisfactory basis.

It was in connection with the latter problem more particularly that I undertook the investigation upon which I have recently been engaged, some of the results of which it may be worth while at this stage to place on record.

Although the scientific investigation of coal may be said to fall almost entirely within the last forty years, it had for long been a matter of common knowledge that the minerals included under this generic title varied in properties to an almost unlimited extent, and particularly so in respect of the physical character of the residues left on igniting them in absence of air. W. Stein ("Chemische und Chemischtechnische Untersuchung der Steinkohlen Sachsens," 1857) was the first to show that two coals may possess practically the same composition and yet give carbonaceous residues entirely different in character and quantity—the one yielding a true "coke," and the other only "sintering," or even leaving a loose non-coherent powder. (Percy, "Metallurgy," vol. 1, "Fuel," p. 308.)

Marsilly ("Annales de Mines," s. 5, 1857, xii., p. 347 *et seq.*)

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* *cf.* Knublauch (Jr. für Gasbeleuchtung, 38, 753-758 and 769-773; also Jr. Soc. of Chem. Ind., 1896, pp. 106, 107), who gives as the result of distilling Westphalian coal:—12·14 per cent. of the nitrogen converted into ammonia, not quite 2 per cent. into hydrocyanic acid, 30 per cent. as free nitrogen in the gas, and *50 per cent. left in the residual coke.*

put forward the view that all caking coals from pits in which fire-damp occurs lose the property of caking on being heated to 300° C., and that if subsequently ignited in a closed crucible in powder they will yield a pulverulent residue. This result, as well as the observed fact that the caking property deteriorates when coals are allowed to be exposed to air, Marsilly explained by ascribing it to the volatilization of matter upon which the coking property depended.

Percy (*op. cit.*, p. 309) states that he has confirmed these observations by experiments on the strongly caking coal of Newcastle, which, after exposure to a temperature of 300° to 304° C. for one or two hours, no longer swells up and cakes on ignition, but yields only a slightly fritted coke. H. Fleck, at the time assistant to Stein at Leipzig, and afterwards Professor at Dresden, came to the conclusion that the hydrogen in coal is partly united directly to the carbon and in part through the medium of oxygen. The former he designated "free" and the latter "combined hydrogen," and with the presence and relative proportion of the former he connected the property of caking and sintering possessed by certain coals. This view was combated in 1871 by E. Richters, of the Mining School at Waldenburg, who ascertained that in general the yield of coke is diminished if the coal contains much oxygen, and especially if a large percentage of hydrogen is present. Richters further established the fact that coal on lying exposed to air, and still more on gentle heating, readily absorbs oxygen with increase of weight, and with liberation at the same time of carbonic acid and water. Richters' work will be found in "Zeitsch. für Berg-Hutten u. Salinen Wesen in Preuss. Staat," 1871, and "Dingler's Polyt. Jour.," vols. 119, 193, 195; also in "Untersuchungen über die Veränderungen Welche die Steinkohlen beim lagern an der Luft Erleiden."

In 1873 Gruner ("Ann. de Mines," 1873, p. 169; "Dingler's Polyt. Jour," 213, p. 244), as the result of a large number of analyses of coals from various localities, came to the conclusion that a definite relation existed between the proportion of oxygen and hydrogen in the coal, the percentage of coke residue left on ignition, and the physical properties of the latter, and this relation, he believed, could be made a basis of classification. Such an assumption, however, the researches of Richters, Muck, and others have proved to be entirely unwarranted. The work of F. Muck, Professor of Chemistry in the Mining School at Bochum,

added considerably to the knowledge of the subject. The results are principally contained in his "Chemische Aphorismen über Steinkohle," published in 1873; "Chemische Beitragen zur Keuntniss der Steinkohle," in 1876; and "Die Chemie der Steinkohle," in 1881. With reference to the point of isomerism among coals, Muck showed by experiments upon the isomeric carbohydrates, starch, cellulose, and gum, that differences in the physical character and weight of the fixed carbon residue may be found in the case of other organic bodies of identical percentage composition besides coal. For the substances mentioned he found the following:—

	STARCH.	CELLULOSE.	GUM.
Fixed Carbon,	11·30 %	6·71 %	20·42 %
Residue—	Fused, strongly swollen.	Unfused, original form unchanged.	Denser and less lustrous than the former.

Regarding the origin of the property of coking, Muck expresses the following opinion:—"The property of melting or not melting depends on the presence or absence of certain carbon compounds, regarding which further knowledge will never be obtained, least of all in the way of quantitative estimation." ("Chemie der Steinkohle," 2nd edition, 1891, p. 25.)

In 1874 Dondorff pointed out the existence in certain Westphalian gas coals of thin plates of a blackish substance possessing a reddish brown colour in reflected light, which dissolves almost completely in ether, forming a light yellow fluorescent solution. The quantity of this substance was very variable, and ranged from 0 to ·3 °/₀ of the coal matter. Dana ("Mineralogy," p. 745) and Muck ("Chemie der Steinkohle," 2nd edition, p. 66) refer to such soluble bodies, and differentiate between those extracted by various solvents. It may well be doubted, however, whether these bodies are anything more than mixtures. Other investigators in this line are P. Siepmann ("Preuss. Zeitsch. für Bergwesen," 39, s. 27,1891); H. Reinsch ("Jr. für praktische Chemie," 1880 [2], 22, 188-191); P. Reinsch (Dingler's "Polyt. Journal," 256, pp. 224-226); E. Guignet ("Comptes Rendus," 88, pp. 590-592); and Watson Smith ("Jr. Soc. of Chem. Ind.," 1891, p. 975).

On treatment with liquid oxidizing agents all coals, even anthracites, are converted with more or less completeness into dark brown or black lustrous bodies, sparingly soluble in water,

but very readily soluble in caustic alkalis, alkaline carbonates, and ammonia, forming intensely brown coloured solutions. These have been obtained by Schulze, of Rostock, by treating coal with chlorate of potash and nitric acid; by Jacobsen ("Chemisch technisches Repertorium," 1877) by the use of permanganate of potash and sulphuric acid; and by R. J. Friswell ("Proc. Chem. Soc.," 1891-92, p. 9) with dilute nitric acid. J. A. Smythe ("Brit. Assoc. Committee's Rep.," 1896) has obtained chlorinated compounds of variable composition by treating coal with chlorate of potash and hydrochloric acid. Saville Shaw (*Ibid.*) treated coal for three weeks with a mixture of concentrated sulphuric and nitric acids, after which it was poured into a large bulk of water. The carefully washed and dried residue showed little change in outward appearance, but gave 77 °/₀ of volatile matter on ignition, as compared with 27 °/₀ in the original coal.

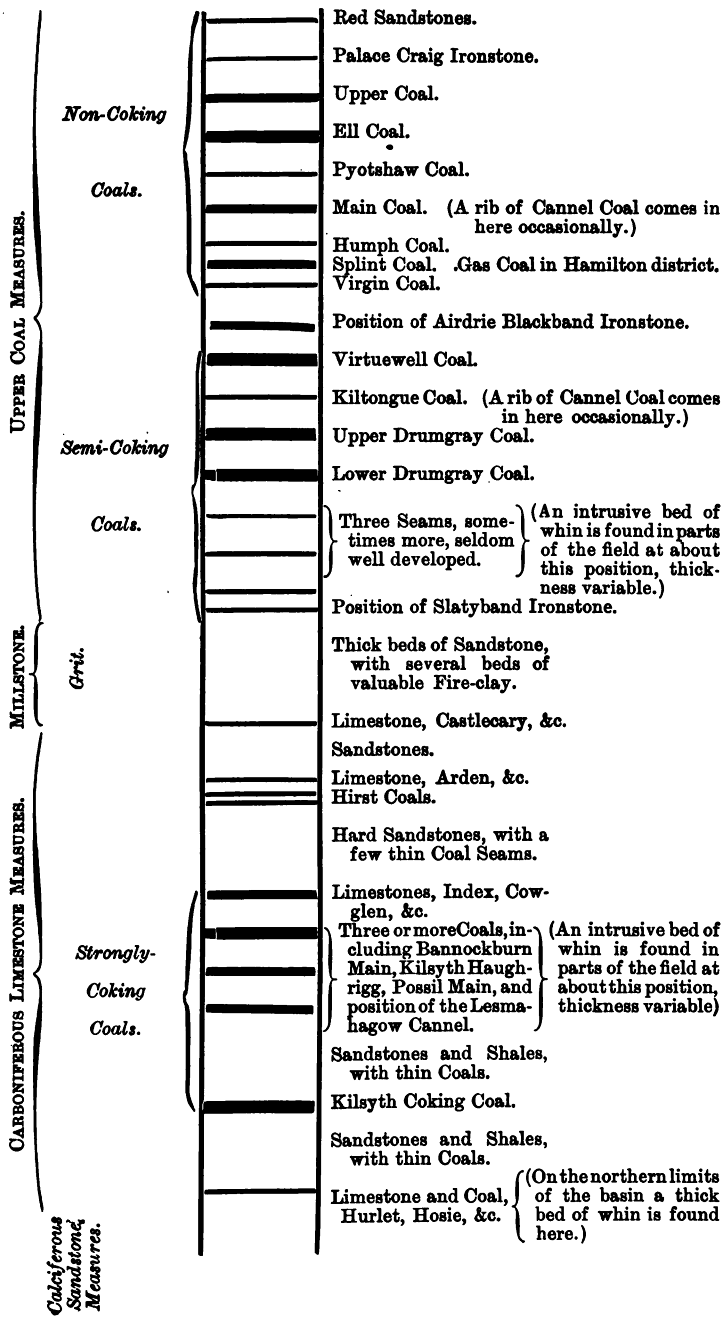
On the general question the following papers and works may also be referred to:—E. J. Mills' "Cumulative Resolution," (Phil. Mag., 1877); E. J. Mills' "Destructive Distillation," 1st edition, 1877, 4th edition, 1897; Cross and Bevan, "Chemistry of Bast Fibres" ("Jr. Chem. Soc.," vol. xli., pp. 90-110); and Schinnerer and Morawsky ("Ber. der deut. Chem. Gesell.," iv., p. 185).

The coals in the upper part of the Clyde Basin series are entirely non-coking in character, and those lying between the position of the Palace Craig Ironstone and the Airdrie Blackband Ironstone are not used for coking purposes in any part of the district.

The Ell Coal is a bright black coal with cubical fracture and a brownish coloured ash. It usually contains some hard ribs of Splint Coal and a portion of the seam is contaminated with nodules of iron pyrites ("brasses"). The vertical "backs" are usually filled with a thin layer of calcareous matter, which seems to have been deposited from solution in water. The coal is brittle and soon breaks up on exposure to the weather. It is a good household coal, and where found in its best condition the large coal is sold exclusively for this purpose. The small coal is a valuable fuel for steam raising. A few attempts have been made to manufacture metallurgical coke from the small coal, but they have not been successful.

The Pyotshaw Coal is very variable in quality and thickness, is similar in character to the Splint Coal described below, but is much coarser in appearance and contains more ash.

GENERAL SECTION OF THE CLYDE COAL BASIN.



The Main Coal is a bright black coal with cubical fracture and a white ash. It contains, as a rule, three ribs of hard splinty coal of considerable thickness. In some districts a rib of Cannel Coal of fair quality is present, and over a large area the thickest splinty rib, called the "pugs," is found to yield a fair quantity of gas of about 19 candle-power. The hard ribs are for the most part used for gas-making and the bright black coal is a fair household coal. The vertical "backs" are filled with a calcareous deposit as in the Ell Coal. The coal is very brittle and soon falls to pieces on exposure to the weather. This coal is never used for the manufacture of metallurgical coke. The portion used for gas-making, when distilled in the retorts, yields a soft friable coke of little value.

The Splint Coal is hard and strong and possesses a dull blue-black colour. It splits easily along numerous beds parallel to the plane of stratification, but is difficult to break vertically except at the "backs" which, as a rule, are not numerous, so that this coal is got in large lumps, which do not readily fall to pieces even after exposure to the weather. It is chiefly used for smelting iron in blast furnaces and for gas-making. It is never coked.

The Cannel Coal, that in the Hamilton district is found separating the Splint Coal from the Virgin Coal, is a hard brittle coal with smooth conchoidal fracture. There is usually a rib of bright coal between the Splint and the Cannel which does not readily part from the latter, and the change from bright black coal to Cannel is not marked by a distinct line or bed of stratification, although the change is sharp. This seems to indicate that, whatever may have been the process by which these two qualities were produced, the change of conditions was sudden, but the process continuous. (*Query*—A change in the nature of the vegetable substance?)

Virgin Coal is a bright black coal, coarser and stronger than the Ell Coal. It is a fair household coal and is not used for coke-making.

Virtuewell Coal is similar in appearance to the Virgin Coal. In some districts it is a first-class house coal and is sometimes used to make an inferior quality of coke.

Upper Drumgray Coal is, as a rule, a hard blue-black coal, suitable for furnace purposes. In the Slamannan district the intrusive whin seems to have materially affected the quality of this seam, converting it into a steam coal of very good quality.

In many places the small has been used for coking purposes, and, where the action of the whin has not been excessive, it is a valuable coking coal. The near approach of the whin has in some places destroyed the coking properties and rendered the coal semi-anthracitic.

The Lower Drumgray is a bright black coal, sometimes a first-class house coal, but always much softer than the Upper Drumgray. Like the Upper Drumgray, it is altered in character by the intrusive whin, and the same remarks apply.

The remaining seams above the Slatyband Ironstone are developed to a workable extent only in the eastern portion of the Clyde basin, chiefly in the district between Shotts and Falkirk. Their quality is, as a rule, inferior, and they are subject to the above-mentioned action of the whin. At their best an inferior coke is made from the small.

From the Slatyband Ironstone to the position of the Index Limestone the few coals which are found are inferior in quality.

Below the Index Limestone is a group of coals of a strong coking quality, well developed and largely worked on the northern outcrop of the basin, but of little value on the south. The seams vary very much in thickness, and it is not possible to trace each one for any distance. All that can be safely affirmed is that the Possil Main, Kilsyth Haughrigg, Bannockburn Main, Kinneil and Wilsontown Main are the thickest seams of this group in their respective districts. In appearance they are all more or less alike. They are soft black coals of irregular fracture, easily affected by exposure to the weather, and have not the calcareous deposit mentioned above filling the fractures. Where the intrusive whinstone is absent or remote, these coals will all make coke, the quality of which varies, but in general it is hard, with strong metallic ring, and much superior for metallurgical purposes to that made from the coal of the Upper Measures. Where the intrusive whin is near, the coking properties are destroyed, and the coal becomes semi-anthracitic, and in a few cases a true anthracite with glassy fracture is produced.

Kilsyth Coking, or Banton Main, Coal is a well-defined position over a large area, but is best developed in the immediate neighbourhood of Kilsyth. The characteristics are similar to the above, and from it a first-class coke is made.

In the investigations which I undertook, with a view more particularly to finding out points of difference in character and

reaction between coals which might be regarded as non-coking* and those which are true coking varieties, I experimented upon samples of the principal seams belonging to the upper and lowest divisions of the Clyde basin series, carefully selected for me by Mr. Wallace Thorneycroft, of the Merryton and Plean Collieries, to whom I would here express my cordial thanks for much valuable assistance. I desire further to acknowledge the loyal co-operation of my friend Mr. James Roberts, of the University Laboratory, who from first to last has ably assisted me in carrying out these experiments.

In the Clyde basin it may be generally affirmed that the coking property increases with depth, although this cannot be predicated as a constant feature of all coalfields.

The subjoined tables give the ultimate and proximate analyses of the samples employed; the relative stratigraphical position of the seams will be seen by referring to the preceding geological section:—

TABLE I.

	Ell Coal.	Main Coal.	Splint Coal.	Gas Coal.	Virgin Coal.	Kilsyth Haugh-rigg Coal.	Bannock-burn Main Coal.	Kilsyth Coking Coal.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrogen, ...	4·52	4·98	4·82	5·54	5·10	5·06	5·14	5·20
Carbon,.........	71·88	73·62	75·50	76·16	74·67	80·67	82·80	81·50
Oxygen, ...	11·10	9·50	8·71	7·52	8·62	7·50	5·67	7·53
Nitrogen,......	1·53	1·54	1·50	1·52	1·54	1·84	1·89	2·04
Moisture,......	9·99	9·08	7·27	5·56	7·77	1·98	1·75	1·72
Ash, ...	·98	1·28	2·20	3·70	2·30	2·95	2·75	2·01
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE II.

COMPOSITION OF ABOVE COALS CALCULATED ON DRIED SAMPLES.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrogen, ...	5·02	5·47	5·20	5·87	5·53	5·16	5·23	5·29
Carbon,.........	79·87	80·97	81·42	80·63	80·97	82·30	84·28	82·93
Oxygen, ...	12·33	10·45	9·39	7·97	9·34	7·65	5·77	7·66
Nitrogen,......	1·70	1·71	1·62	1·61	1·67	1·88	1·92	2·08
Ash, ...	1·08	1·40	2·37	3·92	2·49	3·01	2·80	2·04
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

* In this paper I use the term "non-coking" as meaning nothing more than that such coals are not capable of being employed for the manufacture of metallurgical coke. As a matter of fact, all the coals referred to above "coke" to the extent of giving coherent residues on ignition.

TABLE III.

COMPOSITION OF THE DRY ASH-FREE COALS, CALCULATED FROM THE FOREGOING.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrogen, ...	5·07	5·56	5·32	6·11	5·67	5·32	5·38	5·40
Carbon, ...	80·74	82·13	83·41	83·92	83·03	84·86	86·70	84·67
Oxygen, ...	12·47	10·59	9·62	8·29	9·59	7·89	5·94	7·82
Nitrogen, ...	1·72	1·72	1·65	1·68	1·71	1·93	1·98	2·11
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Combined* Hydrogen,	1·56	1·32	1·20	1·04	1·20	·98	·74	·98
Disposable Hydrogen,	3·51	4·24	4·12	5·07	4·47	4·34	4·64	4·42
Ratio $\frac{\text{Disposable H}}{\text{1000 Carbon}}$	43·47	51·62	49·39	60·41	53·84	51·15	53·50	52·20

TABLE IV.

PROXIMATE ANALYSES OF THE ABOVE SAMPLES.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent,	Per cent.
Moisture, ...	9·99	9·09	7·27	5·56	7·77	1·98	1·75	1·72
Ash, ...	·98	1·28	2·20	3·70	2·30	2·95	2·75	2·01
Volatile Matter,	33·33	35·84	36·22	38·25	33·53	32·55	27·40	28·45
Fixed Carbon,	55·70	53·79	54·31	52·49	56·40	62·52	68·10	67·82
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE V.

SPECIFIC GRAVITIES AND CALORIFIC VALUES.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
Sp. Gravity,	1·266	1·261	1·292	1·290	1·286	1·291	1·306	1·275
Calorific Value (Thompson's Calorimeter)	7480	7590	7425	7370	7480	7535	7865	7810

* These relations have been founded upon as affording a constant and well-marked distinction between coking and non-coking coals. It is true that *generally*, in coking coals, the percentage of, so-called, combined Hydrogen $\left(=\frac{\text{oxygen}}{8}\right)$ is lower than in non-coking; but it will be obvious, from a comparison of these figures with those in Tables IV. and VI., that no reliance can be placed upon such data as an index to the degree of coking power, or even to the percentage yield of "fixed carbon."

For the purpose of obtaining a comparative estimate of the caking power of these coals I employed the simple test given by M. Louis Campredon, which consists in igniting one grm. of the coal with the largest quantity of fine white sand which it is capable of binding into a mass that just coheres. The weight of sand in grammes is the "caking index." Tested in this way the samples gave the following results:—

TABLE VI.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
Caking Index,	4+	4	3·5	3·5 –	4	9+	15·5	16+

The last three are true caking coals, and are all used for the production of high-class foundry coke. In the crucible they give strongly-swollen, hard, metallic-looking "cokes." The Main and Ell Coals give slightly swollen coke residues in the crucible, while the residues from Splint, Gas, and Virgin are flat or slightly concave cakes of less bulk than the original coal. None of these is anywhere employed for coke-making.

Extraction with Solvents.—In the endeavour to find some difference between the two classes of coking and non-coking coals, recourse was had in the first instance to the use of solvents. After some preliminary trials, it was resolved to extract first of all with cold gasoline, and afterwards to further treat with cold carbon disulphide. In the first case the dried samples (20 grms.) were left in contact with 200 ccs. of the solvent for six days with frequent shaking. The gasoline solutions were of a pale yellow colour with strong blue fluorescence, and on evaporating off the solvent the residual extracts were found to be almost completely volatile at 99° C. The extracts were pale yellow oils similar to one another in appearance, except that from Bannockburn Main Coal which was darker in colour and more viscous.

The samples freed from gasoline were allowed to remain in contact with cold carbon disulphide (200 ccs.) for ten days. The solutions were of a dark yellow colour with faint greenish fluorescence, and, on evaporating off the solvent, dark-brown solid bodies were left, which possessed a distinctly resinous odour. These extracts were only slightly volatile at 99° C.

TABLE VII.

Sample.	Wt. of Gasoline Extract after 1¼ hours at 99°.	Wt. of Gasoline Extract after 7¼ hours at 99°.	Wt. of CS_2 Extract after 1¼ hours at 99°.	Wt. of CS_2 Extract after 7¼ hours at 99°.
Ell,	·878 %	·071 %	·448 %	·428 %
Main,	·851 "	·141 "	·659 "	·609 "
Splint,	·620 "	·046 "	·468 "	·445 "
Gas,	·498 "	·105 "	·537 "	·518 "
Virgin,	·584 "	·061 "	·497 "	·477 "
Kilsyth Haughrigg,	·524 "	·048 "	—	—
Bannockburn Main,	·453 "	·150 "	·881 "	·699 "
Kilsyth Coking,	1·355 "	·062 "	·466 "	·402 "

TOTAL EXTRACTED MATTER (GASOLINE AND CS_2).

Ell,	1·326 %	Virgin,	1·081 %
Main,	1·510 "	Haughrigg,	—
Splint,	1·088 "	Bannockburn Main,	1·334 "
Gas,	1·035 "	Kilsyth Coking,	1·821 "

The bodies thus obtained are doubtless similar in character to those obtained by Muck, Siepmann, and others; but as it was found that they were not present in greater quantity in coking coals than in non-coking, and that, moreover, their removal exercised little, if any, deteriorating effect upon the coking property, the investigation of them was not pursued further.

Treatment with Caustic Potash.—A grm. of each of the coals was boiled for one hour with 100 ccs. of a 5 °/ₒ solution of caustic potash, and the residue filtered off and carefully washed till free from alkali. In the case of Ell, Main, and Virgin Coals the filtrate was dark coffee-brown in colour, and from it a small quantity of a brown humus-like substance was precipitated on acidifying. Splint and Gas Coals gave a pale amber-coloured filtrate, while the true coking coals gave only the faintest trace of colour, more distinct in the case of Haughrigg than in the other two.

On igniting these extracted samples in a closed crucible in the usual way, it was found that in the case of the first five all tendency towards cohesion had disappeared, and the residues were loose, dull, earthy-looking powders, several per cents. higher in weight than the "cokes" got from the dry untreated coal. In the case of the three coking coals, boiling for even three hours with 5 °/ₒ caustic potash appeared to cause very little deterioration in the coke.

Treatment with Nitric Acid.—Having found that boiling with dilute potash gave different results (colour of solution and condition of coke residue) with different coals, recourse was had next to nitric acid. Two grms. of the dry coal were mixed with 25 ccs. of nitric acid (sp. gr. 1·4) in a small beaker packed in cotton wool, and the rise in temperature noted. In each case the rise ceased in about seven minutes; in the case of Main in five minutes.

TABLE VIII.

	Degrees Rise.		Degrees Rise.
Ell Coal,	17·00 C.	Virgin,	15·25 C.
Main,	17·75 "	Kilsyth Haughrigg,	17·00 "
Splint,	13·50 "	Bannockburn Main,	17·00 "
Gas,	13·25 "	Kilsyth Coking,	17·00 "

One grm. of each coal was evaporated to dryness with 20 ccs. of dilute nitric acid (sp. gr. 1·2) on a water bath, and the residue dried at 105° C. till constant. In each case a gain in weight was recorded, but these differed considerably in amount.

TABLE IX.

	Increase in Wt. per cent. =	Per cent. of Dry Coal.
Ell Coal,	10·33	11·47
Main Coal,	9·52	10·47
Splint Coal,	16·61	17·91
Gas Coal,	15·42	16·33
Virgin Coal,	12·17	13·19
Kilsyth Haughrigg Coal,	18·16	18·53
Bannockburn Main Coal,	23·31	23·73
Kilsyth Coking Coal,	23·10	23·51
Bannockburn Main Coal, after previous partial oxidation in air till coking power had been completely lost,	9·98	9·98

Oxidation of Coal.—The researches of Richters proved that there is present in coals a constituent capable of undergoing easy oxidation, especially at slightly elevated temperatures. This oxidation causes the coal to increase in weight so long as it is carried on below a limit which in the generality of cases may be put at about 190° C., beyond which point the volatilization of certain constituents causes usually a nett loss in weight. The following results will show to what extent this takes place in a coking and non-coking coal. In each case one grm., in a finely powdered condition, was heated in a porcelain crucible packed in asbestos within a larger one of metal.

TABLE X.

	Heated for 4 hours at 300° C. Loss.	Residue Ignited. Further Loss.
Bannockburn Main Coal,	44·02 %	12·50 %
Gas Coal,	56·98 %	8·40 %
	Heated for 4 hours at 250° C. Loss.	**Residue Ignited. Further Loss.**
Bannockburn Main Coal,	17·08 %	25·94 %
Gas Coal,	31·82 %	18·46 %
	Heated for 4 hours at 200°—205° C. Loss.	**Residue Ignited. Further Loss.**
Bannockburn Main Coal,	3·94 %	28·06 %
Gas Coal,	14·84 %	31·00 %
	Heated for 1 hour at 160° C. Gain.	**Weight of Residue left on Ignition.**
Bannockburn Main Coal,	1·98 %	78·02 %
Gas Coal,	·90 %	59·96 %

Bannockburn Main Coal heated for 33 hours in an air-bath at 115° to 120° C. showed a gain in weight of 1·96 %. The weight of the residue left on ignition was 75·66 %.

The ignited residues from both Bannockburn Main and Gas Coal after these had been heated for four hours at 300° C. cohered below, but were in the form of loose dull powder above. In the other experiments the residues left by both were loose powders without any trace of cohesion, even when the previous heating was only for one hour at 160° C. The gases given off on ignition in these cases were non-luminous, and the residues showed on the surface a thin layer of finely-divided carbon in the form of small rods, apparently resulting from the decomposition of a complex carbon compound.

In order to make certain that this loss of coking property was due only to oxidation, and was not a result induced by simple heating at comparatively low temperatures, the experiment was repeated with Bannockburn Main Coal at 160°, in an atmosphere

of carbon dioxide. Two experiments gave, instead of a gain as above, losses of 1·77 °/₀ and 1·85 °/₀, and the residues on ignition left a bright silvery coke, similar to those got from the original coal, and weighing 74·5 °/₀ of the heated sample. Similar results were got with Kilsyth Coking and Kilsyth Haughrigg Coals.

To show the rate at which this oxidation proceeds, the following results of heating one grm. of powdered Bannockburn Main Coal in an air-bath at 140° to 150° may be cited:—

TABLE XI.

BANNOCKBURN MAIN COAL HEATED IN AIR AT 140°-150° C.

Time.	Gain in Weight.
In first 7 hours,	1·012 %
In next 22 hours,	1·335 ,,
In next 26½ hours,	·857 ,,
In next 42½ hours,	·874 ,,
In next 47 hours,	·621 ,,
In next 57 hours,	·467 ,,
Total, 202 hours.	Total Gain, 5·166 %

The effect of this oxidation upon the composition of the coal is seen below:—

	Original Composition of Coal.	After Oxidation as above.
Hydrogen,	5·39 %	4·49 %
Carbon,	86·70 ,,	78·16 ,,
Oxygen and Nitrogen,	7·91 ,,	17·35 ,,
	100·00 %	100·00 %

The fixation of oxygen is accompanied by an evolution of carbon dioxide and water. A comparison of the rate at which both processes go on at different temperatures was made by heating samples of Bannockburn Main Coal at 99° C. and at 160° C., with the following result:—

TABLE XII.

DRY BANNOCKBURN MAIN COAL, HEATED FOR 54 HOURS AT 99° C.
(WEIGHT OF SAMPLE, 2·7605 GRMS.)

Time.	Gain in Wt. of Sample.	H_2O produced.	CO_2 produced.
First 6 hours,	− ·0049 grm.	+ ·0035 grm.	+ ·0008 grm.
Second 6 hours,	− ·0030 ,,	+ ·0156 ,,	+ ·0004 ,,
Third 6 hours,	+ ·0020 ,,	+ ·0076 ,,	+ ·0006 ,,
Fourth 6 hours,	+ ·0038 ,,	+ ·0124 ,,	+ ·0000 ,,
Fifth 6 hours,	− ·0046 ,,	+ ·0106 ,,	+ ·0016 ,,
Sixth 6 hours,	− ·0008 ,,	+ ·0062 ,,	+ ·0014 ,,
Seventh 6 hours,	+ ·0016 ,,	+ ·0074 ,,	+ ·0014 ,,
Eighth 6 hours,	− ·0012 ,,	+ ·0170 ,,	+ ·0020 ,,
Ninth 6 hours,	− ·0068 ,,	+ ·0096 ,,	+ ·0010 ,,
Total, 54 hours.	Nett Loss, ·0139 grm. = ·503 %	H_2O = ·0896 grm. = ·01 grm. H	CO_2 = ·0092 grm. = ·0025 grm. C.

The residue on ignition gave a good strongly swollen coke, weighing 73·36 °/₀.

TABLE XIII.

DRY BANNOCKBURN MAIN COAL, HEATED FOR 60 HOURS AT 160° C.
(WEIGHT OF SAMPLE, 2·6910 GRMS.)

Time.	Gain in Wt. of Sample.		H_2O produced.		CO_2 produced.
First 6 hours, ...	+ ·0191 grm.	...	·0196 grm.	...	·0052 grm.
Second 6 hours, ...	+ ·0210 ,,	...	·0350 ,,	...	·0136 ,,
Third 6 hours, ...	+ ·0140 ,,	...	·0240 ,,	...	·0174· ,,
Fourth 6 hours, ...	+ ·0118 ,,	...	·0166 ,,	...	·0090 ,,
Fifth 6 hours, ...	+ ·0128 ,,	...	·0188 ,,	...	·0132 ,,
Sixth 6 hours, ...	+ ·0090 ,,	...	·0194 ,,	...	·0104 ,,
Seventh 6 hours,...	+ ·0062 ,,	...	·0176 ,,	...	·0094 ,,
Eighth 6 hours, ...	+ ·0080 ,,	...	·0186 ,,	...	·0104 ,,
Ninth 6 hours,......	+ ·0030 ,,	...	·0160 ,,	...	·0122 ,,
Tenth 6 hours,......	+ ·0034 ,,	...	·0166 ,,	...	·0110 ,,
Total, 60 hours.	Total Gain, ·1083 grm. = 4·025 %		Tl. H_2O = ·2022 grm. = ·0224 grm. H		Tl. CO_2 = ·1118 grm. = ·0305 grm. C.

The residue when ignited did not coke, but left a loose dull powder, weighing 74·08 °/₀.

The experiments described above with caustic potash and with nitric acid, as well as the calorific values and coking indices of the coals, suggested that they may be divided into three classes—the first represented by Ell and Main, the second by Splint and Gas, and the third by Bannockburn Main and Kilsyth Coking Coal. The Virgin Coal seemed to stand midway between the first and second classes, and Kilsyth Haughrigg between the first and third. The percentages of nitrogen found in the samples appeared further to support this view. In the endeavour to ascertain how far it was correct, it appeared possible that some light might be got by carrying out the oxidation of the coals to the limits represented by their ceasing to gain in weight, and afterwards determining the composition of the products. Richters ("Dingler's Polyt. Jr.," 195, p. 315) showed by his experiments that this gain in weight goes on up to a point beyond which a slight decrease is noted, and then the weight remains apparently constant. In the specimens which he employed he found that the maximum weight was reached after 20 hours heating at 180°-200° C. In carrying out the operation upon the above-mentioned samples, we found that the oxidation went on very rapidly during the first 12 to 24 hours, but that thereafter a slow increase in weight continued for a long time, and that the period required to complete the process (and also the increment in weight) varied greatly in the different coals.

TABLE XIV.

NUMBER OF HOURS REQUIRED FOR OXIDATION AND NETT GAIN IN WEIGHT OF COALS.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
Hours required to complete Oxidation,	47	40	35	33	49	49	78	112
Nett Gain in Weight of Coal per cent.,	4·15	3·95	3·92	3·82	4·23	5·13	6·44	6·79

The composition of the resulting oxidized products is seen from the following table. In each case the coal was heated for six hours after the increase in weight had ceased:—

TABLE XV.

COMPOSITION OF BODIES GOT BY OXIDIZING COALS IN AIR AT 180°-190° C. TILL GAIN IN WEIGHT HAD CEASED.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrogen, ...	3·92	3·95	4·35	4·45	3·97	3·88	3·90	3·90
Carbon, ...	71·44	71·19	74·33	71·84	71·67	71·35	75·84	74·75
Oxygen and Nitrogen,	23·54	23·53	19·04	19·96	22·34	21·80	17·75	19·60
Ash, ...	1·10	1·33	2·28	3·75	2·02	2·97	2·51	1·75
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE XVI.

COMPOSITION OF ASH-FREE ORGANIC MATTER IN ABOVE BODIES.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrogen, ...	3·97	4·00	4·45	4·63	4·05	4·00	4·00	3·97
Carbon, ...	72·23	72·15	76·07	74·63	73·15	73·53	77·79	76·08
Oxygen and Nitrogen,	23·80	23·85	19·48	20·74	22·80	22·47	18·21	19·95
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

Products of Oxidation with Nitric Acid.—In order to examine further the difference between these classes of coal substances by the method of oxidation, an attempt was made to prepare, in a partially purified condition the brown acid bodies got by acting on Ell, Splint, and Bannockburn Main Coals with nitric acid. About five grms. of each were evaporated to dryness over the

water bath with 200 ccs. of nitric acid (sp. gr. 1·2), the residue dissolved as far as possible by ammonia, and the filtered solution reprecipitated by hydrochloric acid. This process was repeated, and the insoluble acids were frequently washed by decantation. The bodies thus obtained are insoluble in water containing mineral acids or salts in solution, but are fairly soluble in pure water. They were afterwards thrown on a filter, washed as far as possible with water, and finally dried for some days at 105° C. The acids from all three coals contained nitrogen, and had the following composition:—

TABLE XVII.

COMPOSITION OF ACID BODIES PREPARED FROM COAL WITH NITRIC ACID.

	Ell Acid.	Splint Acid.	Bannockburn Main Acid.
Hydrogen,	3·15 %	3·20 %	3·33 %
Carbon,	58·45 ,,	62·31 ,,	62·64 ,,
Oxygen and Nitrogen,	37·87 ,,	33·14 ,,	33·40 ,,
Ash,	·53 ,,	1·35 ,,	·63 ,,
	100·00 %	100·00 %	100·00 %

TABLE XVIII.

COMPOSITION OF ORGANIC MATTER IN ABOVE.

	Ell Acid.	Splint Acid.	Bannockburn Main Acid.
Hydrogen,	3·17 %	3·24 %	3·35 %
Carbon,	58·76 ,,	63·17 ,,	63·05 ,,
Oxygen and Nitrogen,	38·07 ,,	33·59 ,,	33·60 ,,
	100·00 %	100·00 %	100·00 %

Effect of Heat on the Coking Property.—Percy ("Metallurgy," vol. 1, "Fuel," pp. 308-309) quotes an assertion of Marsilly (*loc. cit.*) to the effect that "all caking coals from pits in which fire-damp occurs cease to swell up and cake when they have been previously heated to 300° C.; so that when they are heated to redness in a covered crucible in the state of powder, after having been heated to 300° C., they will be found in the state of powder afterwards." The correctness of this assertion, he states, he has confirmed with respect to the strongly-caking coal of Newcastle-on-Tyne. "The powder of this coal was heated in the hot-air bath at a temperature varying between 300° and about 304° C. It may be thus heated for about a quarter-of-an-hour without

sensibly losing its property of swelling up and caking ; but when it is kept exposed to this temperature during one or two hours, it does not swell up when subsequently heated to redness, and yields only a very slightly fritted coke."

Marsilly infers that the loss of the caking property which takes place when coal lies exposed to air for a lengthened period, and also when it is subjected to the action of heat under 330° during a short time, is due to the same cause, viz., volatilization of matter upon which the coking property depends.

Now it has been shown above that, if precautions be not taken to exclude air from contact with the coal, a temperature very much lower than 300° C. suffices in one to two hours to destroy completely any tendency towards caking in such high-class coking coals as that of the Bannockburn Main Seam and Kilsyth Coking, but that this is not due to volatilization of the constituent which conditions the caking, but to its oxidation. It does not appear that either Marsilly or Percy took such precautions, and therefore the chief agent at least in producing the results they observed was, in all probability, atmospheric oxygen. To test the assertion further, however, samples of the above coals, coking and non-coking, were subjected to a temperature of 297°—304° C. for three hours in a U tube, through which was passed a slow current of dry carbonic acid gas. The results are tabulated below:—

TABLE XIX.

RESULTS OF HEATING COALS TO 300° C. IN CARBONIC ACID.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haughrigg.	Bannockburn Main.	Kilsyth Coking.
Percentage loss of dry coal on heating,	12·7	16·2	16·2	21·8	17·7	13·1	7·3	6·4
Wt. of residue after ignition (residue at 300° C. = 100),	71·18	74·56	73·43	79·68	72·13	79·33	76·98	72·87
Wt. of ignited residue from dry coal,	62·97	60·50	60·94	59·50	63·60	66·80	72·12	71·03
Increase,	8·21	14·06	12·49	20·18	8·53	12·53	4·86	1·84
Physical condition of ignited residue from coal heated to 300°,	A considerable part in form of a dull earthy coke; the rest in powder.	The residues from these four coals just cohered and no more.				Residue formed a coke, but this was dull & not swollen up	Residues completely coked, but of a duller appearance than before.	

From these figures it may be observed—

(1) That the greatest loss at 300° C. takes place in Splint, Gas, Virgin, and Main Coals—that is, in the long-flaming coals, which have also the lowest coking index; the smallest loss is found in the strongest caking coals, Bannockburn Main and Kilsyth Coking (caking indices, 15·5 and 16), while Ell and Kilsyth Haughrigg, which swell up slightly on ignition in a crucible, occupy an intermediate position.

(2) That the percentage of coke or fixed residue rises enormously after the coal has been heated to 300° C.

(3) That in the coals of which the ignited residues cohered only slightly, and which show the largest percentage loss at 300°, the tendency to cohere is completely destroyed; while in the case of the true coking coals it is, though impaired to some extent, still existent.

These facts, taken along with others previously mentioned, are, I believe, capable of a very simple explanation. In all the coals mentioned we have a set of bodies of a resinoid character, which are capable of extraction with dilute caustic potash solution, and which alone are accountable for the tendency to cohere in the residue from Ell, Main, Splint, Gas, and Virgin Coals. These bodies are not the same in each coal, but vary alike in kind and in quantity. They contribute only to a very slight extent to the weight of the fixed residue got on ignition, being, for the most part, driven off, and constituting a large part of the "smoke," to which they contribute a characteristic smell. They are all more or less completely volatilized below 300° C., except in the case of Ell, where a part seems to remain behind, causing the partial coking of the residue on ignition.

In addition to these there is in the true coking coals a constituent, or a series of constituents, not so readily, if at all, acted on by dilute alkaline solutions, oxidizable, like the main constituent of the non-coking coals, in air, but not volatile at 300° C. We find that both Bannockburn Main and Kilsyth Coking Coals melt in an atmosphere of carbon dioxide at a definite point, which may be placed at 317° C., and this we take to be the melting point of the constituent referred to. In all probability the higher percentage yield of fixed residue usually found as an accompaniment of the coking coals, and which Gruner believed to

be a universal characteristic, is due to the fact that this body, or class of bodies, breaks down on heating into fixed carbon and simpler compounds before being itself volatilized. Active gasification does not appear to begin below 330°, and is not particularly vigorous even at this temperature. The evolution of gas at this stage is perhaps to be traced to the decomposition of the other kind of constituent present in coal minerals, and not to breakdown of the fusible body, which may decompose only at a considerably higher temperature.

Presence of Free Carbon in Coal.—In this paper I desire to avoid anything in the way of abstract theorising on a subject on which, it seems to me, much more experimental work is required before elaborate theories can be of any service. I would advert briefly, however, to a point of some importance, namely, the existence or non-existence of elemental carbon in coals. The view at present almost universally held is that free carbon does not constitute any part of the matter of ordinary coal minerals, and from this view I am not prepared to dissent. At the same time, the point is one on which conclusive evidence is not forthcoming, and is perhaps at the present moment scarcely to be looked for. Muck ("Die Chemie der Steinkohle," 2nd edition, p. 152) advances the fact that, after treatment with nitric acid, coals go almost completely into solution in the form of humus-like bodies containing hydrogen and oxygen as proof that they do not contain carbon as such. But that such evidence is not unimpeachable may be seen by comparing the humus-like acid bodies in Table XVIII., derived in this way from coals, with graphitic acid ("Phil. Trans.," 1859, p. 249), which has the composition:—

Hydrogen, ...	1·85 °/₀
Carbon, ...	61·11 ,,
Oxygen, ...	37·04 ,,
	100·00 °/₀

and which was prepared by Brodie by the action of chlorate of potash and nitric acid on graphite: in this case graphite, a form of native carbon, has been converted by oxidation into a compound containing both hydrogen and oxygen.

The fact that strongly-ignited cokes still contain hydrogen, oxygen, and nitrogen is an argument of no greater validity, since

it might well be that stable compounds of these elements with carbon existed side by side with the latter in the free state.

If, on the other hand, it should turn out, as will probably be found to be the case, that all the acid bodies got as above, by the action of nitric acid on coals, contain nitrogen, and if these can be proved to be simple chemical substances, and not mixtures of two or more, it is a reasonably safe deduction that they are produced by the oxidation of a compound containing nitrogen, which constitutes the bulk of the organic matter of the coal.

With regard to the results of these experiments as a whole, and to the conclusions to be drawn from them, no validity can be at present claimed beyond the particular samples from which they were got. They establish the fact, however, that not only does a difference exist in the degree of the coking property between the coals of the uppermost series of the Clyde basin and those of the lowest, but that this difference is due to the presence of a constituent in the latter which is absent in the former, or is at least present only in very small quantity. The melting point of this constituent is, as near as may be ascertained, 317° C. The main cause of the sintering of the non-coking coals of the upper series is undoubtedly to be found in the resinoid (saponifiable) constituents, which are volatilized completely in a current of dry carbon dioxide at 300° C., with the exception of a small part which still remains in Ell coal at that temperature. Such bodies contribute to some extent likewise to the coking property in the true coking coals. The varying volatility of these substances no doubt explains the fact, which has been often observed, that certain coals will coke in one type of oven where the heat is quickly applied throughout the mass, but will not yield a satisfactory product in ovens of a different kind. Muspratt ("Chemistry," 3rd edition, 1876) instances certain Staffordshire coals which, treated under ordinary conditions, give only brittle fritted coke, but which when subjected quickly to a stronger heat yield a hard product. In the five samples of non-coking coal used in these investigations a connection seems to exist between the quantity of volatile matter at 300° C. and

(1) The total hydrogen in the coal.
(2) The total oxygen.
(3) The disposable hydrogen.
(4) The ratio $\frac{\text{disposable hydrogen}}{\text{1000 carbon}}$ (see Table III.).

The volatile matter at 300° C. increases with increase in the total hydrogen and in the amount of "disposable hydrogen," and conversely diminishes with increase of oxygen. It also increases with increase in the value of the ratio $\frac{D.H.}{1000\ C.}$ Such a connection does not exist in the case of the cóking coals, which affords additional evidence that in these minerals bodies of entirely different composition have to be reckoned with.

With reference to the oxidation of coking coals, which it has been shown takes place very rapidly at temperatures as low as 140° C., this may in certain cases exercise an important influence upon the quality of the coke produced, for example, in bee-hive ovens, where, owing to the thickness of the charge and its low conductivity for heat, the coal in the centre remains in contact with the entangled air for a considerable time at a temperature below that necessary to produce coking of the mass. We have shown that exposure of finely ground coal to a temperature of 160° in a covered crucible, with only limited access of air, completely destroys any tendency towards coking in one to one and a-half hours.

A general feature of coking coals is the presence in them of only a small percentage of water when freshly mined, as may be seen from Table I. This characteristic appears to be due to the non-absorbent nature of the fusible constituent to which reference has been made, since on oxidizing the coal the absorptive power is greatly increased. The following experiment will illustrate this:—A few grms. of Bannockburn Main Coal, in pieces the size of beans, were immersed in a beaker of water for 15 days. The water absorbed amounted to 1·9 °/₀. A similar sample was heated in air till it had gained 2·4 °/₀ in weight, and was then immersed in a beaker of water alongside of the former. At the end of 15 days the water contained in the sample was found to be 6·7 °/₀. The high content of water in Ell, Main, and Virgin Coals is probably to be ascribed to some similar process, since we find that these three coals alone contain humus-like substances extractable with potash, and which can readily be formed in the others by atmospheric oxidation. It is also a fact worthy of note that, although the water content of the non-coking coals is already so high, it increases more rapidly in them (Splint is an exception) than in the others. Thus samples of the above coals left in loosely-corked bottles, in the slightly damp atmosphere of

the laboratory for one year, showed the following percentages of water at the beginning and end of the period :—

TABLE XX.

WATER CONTAINED IN COAL SAMPLES.

	Ell.	Main.	Splint.	Gas.	Virgin.	Kilsyth Haugh-rigg.	Bannock-burn Main.	Kilsyth Coking.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
When freshly mined, ...	9·99	9·08	7·27	5·56	7·77	1·98	1·75	1·72
After one year in loosely-stoppered bottles (powdered), ...	*10·68	10·02	7·20	5·94	8·82	2·16	1·90	1·84
Increase,......	·69	·94	- ·07	·38	1·05	·18	·15	·12

The proportion of water contained in coals may thus be regarded as in some measure an index to the character of the samples, at least for the particular basin to which they belong. Connected, it may be, with this difference in the amount of water contained in coking and non-coking coals, is the peculiarity, which I believe holds not only for the Clyde basin, but for most, if not all, coal areas, that in the non-coking varieties the cracks or "backs" are usually filled with a calcareous deposit, which is entirely absent in the strongly-coking seams.†

Upon the question of the constitution of coals, and the relationships between the constituents of substances so different in properties as the Lanarkshire Ell and Splint and the Bannockburn Main Coal, it would be premature at this stage to venture a suggestion, even of possibilities.‡ One point, however, must be

* The question has sometimes been raised whether the loss in weight which coals undergo at 100° to 105° C. can be regarded as accurately representing the amount of water which they contain. Losses of 10·68 % and 10·02 %, which are found to take place on heating Ell and Main Coal respectively to 105° C., might well be suspected of having arisen from the expulsion of something more than absorbed water, seeing that such coals frequently come from perfectly dry pits, and are themselves to all appearance dry. It seems probable that a small part of the loss thus occasioned is frequently to be ascribed to the volatilization of organic matter. On the other hand, determinations of the loss which the above coals undergo, on standing for 48 hours over sulphuric acid at ordinary temperatures, gave 10·64 % and 10·00 % respectively.

† An examination of this deposit proved that it consisted of practically pure calcium carbonate.

‡ But c/p. Baltzer ("Vierteljahresschift der Züricher natur forschenden Gesellschaft") and Muck ("Chem. der Steinkohle," 2nd ed., 1891, pp. 140, 141).

noted. If we compare the analyses of the coals in Table III. with those of the same coals, after being oxidized in air till they cease to gain in weight (Table XVI.), and these again with the figures for the acid bodies got by treatment of the coals with nitric acid (Table XVIII.), we are at once struck by certain outstanding facts. Thus, Ell and Main Coal, though different at first, yield after atmospheric oxidation products of identical composition, but these are entirely different from the bodies got from all the others. Splint and Gas Coals, although found in seams not far removed from one another, do not show much tendency to approximate in composition when oxidized. Among the coking coals, the original difference in composition between Bannockburn Main and Kilsyth Coking Coals remains in part even after the samples have been subjected to the above treatment, while Kilsyth Haughrigg gravitates towards the class represented by Ell, Main, and Virgin. Splint, on the other hand, shows a tendency to approximate in its composition to that of Bannockburn Main and Kilsyth Coking Coal.

In the acid bodies which were prepared by acting on Ell, Splint, and Bannockburn Main Coals with nitric acid, it is found that the former difference between Ell and the other two still continues, but the products obtained from Splint and Bannockburn Main Coals are practically identical in composition.

What the precise significance of these observations is can only be ascertained by further investigation, and I am hopeful that in time it will be possible to adduce some further evidence on this part of the subject, on which I am still continuing my researches.

V.—*Railway Survey Work in the Shiré Highlands of British Central Africa, with General Observations on the Country between Chinde and Lake Nyasa.* By Mr. GRIEVE MACRONE.

[Read before the Society, 26th January, 1898.]

IN March, 1895, I had the honour of being engaged by the Directors of the African Lakes Corporation, Limited, to proceed to the Shiré Highlands of British Central Africa, to make surveys and reports for a proposed line of railway which would connect the navigable waterways of the Upper and Lower Shiré River. The Directors took this step with a view to opening up the country, being supported by a circular issued by a committee appointed at a public meeting held at Blantyre, in the Shiré Highlands, at which meeting resolutions were framed drawing the attention of capitalists and those philanthropically interested in the development of the country to the great need for a railway between these waterways, and the benefit which would be conferred upon a great tract of country by its construction.

At present goods are taken up the Zambesi and Shiré Rivers from the coast as far as Katunga; above this place navigation is impossible for a stretch of 80 miles, owing to the Murchison Cataracts. Goods have therefore to be carried overland by porters, and are taken first to Mandala, at Blantyre, where the African Lakes Corporation have their headquarters. There they are dealt with for distribution over the country—those for the Great Lake Country northwards being carried on to Matope, on the navigable waterway of the Upper Shiré River. Here the African Lakes Corporation have a station, with steamers plying on the river to Lake Nyasa, where the goods are transhipped into the fleet of lake steamers owned by the Corporation. These carry the goods to the various ports on the lake shore, the most northerly one being Karonga, from where the goods are again carried overland by porters, *viâ* the Stevenson Road and Tanganyika Plateau, to Lake Tanganyika, for distribution on the shores of

that lake, or westwards as far as Lake Mweru and the Congo Free State.

There is thus a great tract of country served by this route, and the inconvenience, delay, and expense attendant upon the porterage overland between the Upper and Lower Shiré Rivers affects the whole area. There is also a great local necessity for the railway in the Shiré Highlands itself. Coffee planting is increasing rapidly and proving successful. A large amount of native labour is required to work these plantations, and it is feared that, unless the labour required for porterage is set free by the construction of the railway, either the coffee plantations or the transport must suffer.

My investigations and surveys did not carry me further than the south end of Lake Nyasa, and I propose in the following article to state a few facts and observations which may prove interesting to you.

I arrived at Chindé (which is situated at one of the mouths of the Zambesi delta) on the 8th of May, 1895, and spent two or three days there while one of the river steamers with barges was being loaded for the journey up the Zambesi and Shiré Rivers. Formerly the main waters of the Zambesi River were reached from Quilimane *viâ* the River Kwakwa, an almost disconnected mouth of the River Zambesi, and it was only in very high floods that a steamer could pass from the one river to the other, which was seldom, and there was the risk of a flood subsiding and leaving the steamer in the Kwakwa with no way of getting out. Goods and passengers were taken up the Kwakwa in row boats and barges, and then carried overland for a short distance to the Zambesi. This was tedious and expensive, and in 1892 the African Lakes Corporation decided to remove these premises to the Chindé mouth of the Zambesi, which had quite recently been discovered to be navigable. A block of land, 25 acres in extent, was leased by the Portuguese to the British Government for offices, stores, &c., in order to deal with the goods in transit for British Central Africa. Other traders soon established themselves, and Chindé has now a population of 86 Europeans of various nationalities, and a good hotel run by a Scotsman.

Chindé is situated on what is really a sandspit of the great Zambesi delta, and its general surface is only five to six feet above high water of ordinary spring tides. The river foreshore on the Chindé Concession is being rapidly washed away, a strip

200 feet wide having disappeared in the past four years, and, unless protective works are built in the near future, Chindé will simply be wiped out.

Ocean coasting steamers, drawing 12 feet of water, can safely cross the bar at full tide and anchor in the Chindé River, so that the ocean coasters and river steamers are in touch with one another. These coasting steamers again connect with mail steamers at Durban, Delagoa Bay, Beira, and Mozambique.

The river steamers are flat bottomed stern-wheelers, drawing from 12 inches to 24 inches of water, the latest and most approved type being 85 feet long by 18 feet beam by 3 feet deep, with draught of 18 inches to 24 inches, depending on cargo and number of passengers. Wood fuel is used, but it is found difficult to keep up steam with it when the steamer has to fight against a strong current, and it is proposed to experiment with coke and coal for more efficient and economic results, Accommodation for 20 passengers is provided. About 20 tons of cargo can be carried, but, as it is so necessary for these steamers to draw as little water as possible, they are made to act more as towing machines than as cargo carriers. Two barges, carrying about 40 tons each, are attached, to hug the steamer one on either side, and this arrangement is found to act very well.

From about 2 miles above Chindé, and all the way above to the Zambesi, a distance of about 70 miles, the banks of the Chindé effluent are uniform and firm, almost canal-like in appearance, and there is always plenty of water for navigation purposes. The stream is about 200 feet wide from bank to bank. The surrounding country is perfectly flat, and covered by dense jungle with open patches.

The Zambesi, from the Chindé effluent to the confluence with the Shiré River, is from half-a-mile to two miles in width, the broader channels being studded with numerous islands. The channels are troublesome to navigate, as they are interspersed with numerous sandbanks, which are continually changing. During the rainy season, from January to April, there is generally plenty of water, but after that period the river gradually falls, and navigation becomes very trying, as steamers run aground frequently, and have to be dragged over the banks by natives, a crew of them being carried for that purpose. Each of this native crew is also furnished with a bamboo pole to help to guide the steamer in tight places and when she has not sufficient steering

way on, and also for pushing off and easing unavoidable concussions with the banks of the river.

New islands are continually forming and old ones being swept away. Roots and trunks of trees washed from eroded banks become grounded, upon which masses of floating vegetation get caught, forming a nucleus down stream from which suspended sediment settles in the slack water caused by the obstruction. This spreads out like a fan, and very soon an island will be formed with a dense growth of grass. While one island may be forming in this way, the current is probably so deflected that some previously formed island is being washed away, or the main bank of the river quite altered, and thus the channels in the river are continually changing.

The Shiré River is in width from 150 to 400 feet. The banks are in general from 10 to 12 feet high, and composed of stiff brown earth, so that little alteration takes place. Navigation from January till July is easy, excepting for several sharp bends where also the current is extra strong and the river narrow. These places are most troublesome when coming down stream, as the steamer is then more difficult to steer, and it is almost impossible to avoid colliding with the banks, and, this being recognised, the steamer is run gently against the bank and allowed to swing round; in fact, she is just made to waltz gently round these bends.

Another troublesome place is called the leak, where part of the river has cut a narrow channel across the neck of a bend in the river. When the water is in flood steamers can go round the bend without difficulty, but when the water is low that channel is closed, and the steamer has to face the narrow short channel, in which the current runs very strong. In order to get through at all towards the end of the dry season the steamer has frequently to throw off her barges, the cargo of which is unloaded and the barges poled through. The cargo is then carried overland for a short distance and reloaded.

It is very noticeable how the speed of one of these river steamers varies when sailing over deep or shallow water. Especially is this so when going down stream. Even when the current is faster in the shallows, the diminution in the speed of the steamer is quite marked. The cause must be that the body of water carried with the steamer is retarded by its friction with the bed of the river, thereby causing more friction between the

hull and the water, besides stirring up the sand, which will make the water heavier.

The general difference in level of the river between the wet and dry seasons is about 4 feet, but floods causing a rise of 10 feet more are not uncommon. These, however, do not last longer than half-a-day or a day at one time, as they are caused by heavy rains in the neighbouring mountains. The River Ruo, which flows into the Shiré at Chiromo, rose 15 feet in a few hours, and partly submerged the township, doing a good deal of damage to stores before they could be removed. The Shiré River was at its ordinary flood level at the time, and so sudden was the flood in the Ruo that its waters were running up stream in the Shiré for about an hour.

It is the waters of Lake Nyasa which keep the Shiré River at a fairly uniform flood level. This, however, can only affect the Zambesi very slightly, as its volume is so much greater than that of the Shiré.

From 1890 to 1895 seems to have been a period with rainfalls much below the average in the Lake Nyasa basin. The lake became lower and lower during that period, and it was remarked by the natives that they had never heard of or seen the river with so little water in it. The rainy season of 1896, however, must have had an abnormally high rainfall, as the lake became higher than it had been for many years, and its waters were still high at the end of the dry season of 1896, so that the 1897 rains really began on a very full lake; therefore, it is likely there will be a period of years with the lake water at a high level, and consequently a good supply of water in the Shiré River.

Chiromo, at the confluence of the Shiré and Ruo Rivers (the latter forming the boundary between the British and Portuguese territories), will be the starting point of the railway. It is prettily situated on a triangular-shaped piece of land between the two rivers. The properties are nicely laid out with shrubs and flowers and beautiful avenues of "Pride of India" trees, the bright emerald green of which is very refreshing after so many shades of dull brown, which is the prevailing tint of the valley. It is 200 feet above sea level, and can at all seasons of the year be reached by the river steamers from Chindé. Above Chiromo the navigation is very uncertain towards the end of the dry season, and sometimes during the period of small rainfalls above mentioned it was quite impossible for steamers to get above Chiromo at all,

and boats and barges had to be resorted to. A steamer to draw only 10 inches of water was constructed for the African Lakes Corporation two years ago, especially for this part of the river, and has been doing very good work.

Katunga, which is as far up as any steamer can go, as already mentioned, owing to the Murchison Cataracts which are just beyond, is about 300 miles from the sea by river, and about 300 feet above sea level. The river has therefore an average fall of one foot to the mile. The average current, I should say, is about three miles per hour, with a maximum of seven miles per hour when the river is in its ordinary flood-level condition.

Katunga is five to ten days' journey from Chindé, depending upon cargo and state of river, which seems a long time to take to travel 300 miles by steamer. But the strength of the current being considered, and the fact that steamers can only run from sunrise to sunset and tie up to the bank during the night, the rate of travel is not so bad. It has been proposed to run the steamers at night with an electric search-light, but experience with that on similar rivers in India has shown that where the channel has to be "read" from the ripple of the water, the glare of the search-light is very misleading, and it is only where the river is narrow, with high banks, or where the channel is marked out with stakes or buoys, that the search-light is any good. When I say that the channel has to be "read," I mean that the depth of the channel is approximately judged from the nature of the ripple of the current. The natives are very good at this, and each steamer carries a native pilot who has a special faculty for judging the channel.

Arriving at Katunga, passengers are conveyed by road to Mandala, at Blantyre, the headquarters of the African Lakes Corporation. This road from Katunga to Blantyre has practically been re-made last year. Hitherto it has been a source of great annoyance, as no provision had been made for draining the water from it, and after each rainy season it was so cut up that it could not be used for vehicular traffic with safety. The gradients were also very steep, as can be seen from the longitudinal section of the road. It is interesting to know that four mules, drawing a heavy Cape cart, containing four passengers and a native driver, made the journey from Katunga to Blantyre in 10 hours, the gradients being then as shown on the section. All the very steep gradients have now been altered, by deviating the road, to 1 in 12, with

the exception of two short stretches, where a gradient of 1 in 10 has been put in to avoid heavy expense which would have been entailed by a 1 in 12 gradient. Proper catch-water drains and dry stone covered-in drains across the road have also been constructed where required, so that it should now be a good road all the year round, with very little cost for upkeep. This work has been carried on by Mr. Binnie, C.E., who was engaged by the African Lakes Corporation to assist me on the railway survey, and whose services have been transferred to the Administration, at their request, for such work.

The rise from Katunga to Blantyre is 3,300 feet, 3,000 feet of which is mounted in 14½ miles. One can understand what hard work it is for carriers taking loads up this hill. Fifty-six lbs. is considered the load for one man, and a carrier generally occupies two days on the journey up to Mandala. Some loads are four to six times that weight, and, of course, require the number of men in proportion, but three to five days is required for the transport of these. Passengers have hitherto been carried in machilas (a hammock arrangement suspended from a pole), which a squad of natives take turn about in bearing—a bearer at each end of the pole. Squads of 8 to 12 men are used for this purpose, and they can accomplish the journey of 27 miles in 7 hours if the passenger is of an ordinary weight. Now, however, that the road has been improved, horses and mules will, no doubt, be used to substitute—a much more dignified, and, at the same time, a more speedy and comfortable mode of travel, until the railway is constructed.

The enterprise of the African Lakes Corporation caused them to send out a traction engine to cope with the transport of goods on this road. It was done as an experiment, and the engine is such that it can be used as a stationary one for driving machinery, if it does not succeed as a traction engine. As a tractive machine it has not proved a success, so far, on the road. This engine is furnished with a winding drum, which enables her to take heavy loads up the steepest inclines. The engine runs up without the wagons and is anchored, the rope on the winding drum is paid out and attached to the wagon, which is then pulled up.

Roads in British Central Africa are not macadamised in any way. As the soil of the country, however, is in general a clayey, red earth, they stand very well during the dry season, and take on a very smooth, hard surface, almost like burned clay. In the rainy season, again, they become soft and muddy, and very easily

cut up. Bridges over streams are of the most primitive description, consisting merely of trunks of trees thrown across a stream, and supported on rough dry stone abutments. The platform for roadway consists of branches laid across these tree trunks and covered with earth. Bridges of this description are dangerous and short-lived, owing to the ravages of white ants and other insects, and it is found much better to construct drifts across the streams. A drift is simply an embankment of rough stones raised across the bed of the stream to any suitable height, through which the water finds its way when the stream is in its normal condition. When in flood the stream may submerge the drift, but if the latter is properly constructed it will not be washed away.

I will now ask you to suppose that I have reached Mandala, the headquarters of the African Lakes Corporation, Limited, and it may interest you if I glance back to the river and give you a very brief account of the birds and animals commonly to be seen there. Once on board one of the comfortable steamers of the African Lakes Corporation, satisfied that all one's baggage is safe, and that he is clear of the sand and insects which make Chindé so disagreeable, the passenger experiences a very pleasurable expectation, if it is his first visit to the country, in looking forward to the journey up the river, with so much that is novel in birds, animals, scenery, and the natives, in prospect. The bird life is most interesting and varied, and I have observed all the following as being quite common:—kingfishers, purple, red, and blue, and black and white; pure white egrets and jet black ones; gulls of various kinds; great varieties of wading birds; comical-looking darters, black in colour, and looking like the caricature of a cormorant; very large storks, white and blue grey; huge marabout storks, in their brilliant plumage, looking like regiments of soldiers; fish eagles, with white body and black wings; the grotesque pelican; vultures; kites and hawks; spun-winged geese; ducks of various kinds; swarms of yellow weaver birds, chattering and fussing round their pendant nests; martins and swallows; brilliant red and blue bee-eaters; and hosts of small birds in the reeds and rushes along the river banks.

Hippopotami are seen disporting themselves, sometimes in herds of a dozen or so and in twos and threes, but these huge beasts are becoming much more wary and shy every year, owing to their being so much shot at from the steamers. They are never, however, likely to become extinct in the Zambesi from that cause, as

there are so many marshes and lagoons branching off from the river far away from the track of steamers. In the Lower Shiré, however, this animal is almost a thing of the past, and is now rarely to be seen, although a few years ago there were great quantities of them, and they were a source of danger to canoes and barges. Not that they make an attack unprovoked, but one might come up to breathe under a barge and throw its occupants into the water, and then a crocodile might come upon the scene. A wounded hippopotamus is dangerous, as it will then attack a boat or anything, even one of its own companions. The hippopotamus can remain under water for a long time without coming to the surface to breathe. I have watched with natives and have noted 20 minutes between the visible periods of coming to the surface to breathe, but this may not be reliable, as these animals, when there is danger about, can come to the surface very gently, perhaps concealing themselves behind a rock or amongst reeds, and only protruding the nostrils, which would be quite easily undetected even by the sharp-eyed natives. Most natives are fond of the flesh of the hippopotamus as food. To preserve it they cut it into strips, which they stretch over a raised openwork platform of bamboos, forming really something like a huge gridiron; they then light small smoky fires underneath, and the strips of flesh are partially cooked and well smoked, which preserves them thoroughly for consumption at leisure. I have tried the most delicate parts of the fresh meat, but did not like it—the taste was coarse and rank. There are some natives, who, though fond of the meat, daren't touch it, as it brings a painful rash out on their bodies, and I have seen some suffering from this after eating the flesh perhaps too heartily. The skin of the hippopotamus is fully an inch in thickness, and the only use I know of its being put to by the natives is to make rods out of it when dried, and such a rod is used for administering punishment. The tusks are exported, but the ivory is coarse and more brittle than elephant ivory, and only fetches about quarter of the price. I have seen the skull of a hippopotamus, which had a peculiar development of the tusks in the lower jaw. The upper tusks had not developed, with the result that there was nothing for the lower tusks to grind themselves upon, and they kept on growing in a curve, almost a complete circle, till they met the molars of the lower jaw which they were displacing.

Crocodiles are still very numerous, and every European who

has a gun considers it a matter of duty to shoot them whenever a chance occurs. They are great pests, and many natives are annually killed by them, but the natives think very little of the danger they run in going into the water, and treat such a matter as being killed by a crocodile in quite a fatalistic spirit. At Fort Johnston, on the Upper Shiré, where there is a large population on the river banks, natives were carried off at the rate of four per week, and they were told to build stockades round the places where they drew water from the river, but they paid no attention until the Administration sent soldiers to compel them to erect these, and they now enjoy comparative immunity from such occurrences. Crocodiles can be seen of all lengths, from one to fifteen feet. The large ones are very alarming to look at, even from a distance.

Heads of buck and buffalo can frequently be seen from the steamer, and occasionally lions are seen. Eight or ten years ago elephants were quite common, but these have entirely disappeared. A large tract of country, from Chiromo to beyond Katunga, has, however, been made a preserve of, in which shooting is restricted, and it is hoped that they may return.

The native population in the Zambesi and Shiré valleys is very large. The soil is highly fertile, and any quantity of cereals, such as rice, maize, and millet, could be grown. The natives only, however, as a rule, grow enough for their own wants. A small trade in ground nuts is carried on by a few Hindoos. The nuts are sent to Marseilles, I believe, where the oil is extracted and prepared for the market as olive oil. The natives are much troubled by birds and wild animals stealing their crops; the hippopotamus is the worst pest in this respect, and watchmen are on duty during the night perched in a hut built on high props, which serves the double purpose of watch-house and grain store, from which they scare away any animals. Boys are on duty during the day to scare away the birds. They stretch strings made from native fibre across the garden, from which small pieces of cloth are hung, and the boy in the watch-house keeps agitating these strings.

There are many canoes, large and small, to be seen on the river. These are dug out from the solid tree trunk, and some of them are neatly made. They are propelled generally with a long bamboo pole, by punting it in the shallow water and using it as a paddle in deep water, the native standing up. Short paddles are

also used, the native then sitting down in the bottom of the canoe. There are many fish in the river, of which the natives are very fond, and are always working about with their nets and traps. There is a nomad class of people who do nothing but hunt the hippopotamus and trade with the dried flesh. Their *modus operandi* is much the same as whale fishing, barbed spears with a line attached being used. The line is allowed to go free, and has a float attached, so that the movements of a speared hippopotamus may be watched, and the animal followed up and speared again and again as opportunity offers.

I will now take your attention back to Mandala, where, when I arrived, I at once began to make preparations for the survey expedition. I was joined there by Mr. Baird, who came out in the steamer following me. He had been in the country before for five years, acting as station agent for the African Lakes Corporation. He thoroughly understood the natives' character and their language, which relieved me of what would have been really more than half the work if I had been without some one with that knowledge. Squads of natives were engaged, a squad consisting of eight to sixteen men, with a headman over them chosen by the squad. The smartest and most likely-looking men were picked out for survey purposes, the others to carry loads. A start was made on 21st of June, 1895. The caravan consisted of Mr. Baird and myself and 60 men carrying provision boxes, two tents with sufficient necessary furniture, surveying instruments, &c.

The first thing to be done was to determine the best place to cross the summit watershed which lay across the route. The question of ease of approach and directness of route, of course, enters into this consideration, and to determine what was best involved a good deal of travelling about and examination of the surrounding country from commanding points. This was a very trying piece of work, as the vegetation consists of tall coarse grass from five to eight feet high, with belts and patches of dense jungle, and nearly the whole country is covered with forest. It often happened that when a commanding point was reached it was impossible to see out from it owing to this vegetation, and even when a tree was climbed only glimpses of the country could be obtained between the foliage. A forest country is most deceptive to the eye. All its ruggedness is smoothed off and its undulations disappear, as the trees grow short on the ridges and

tall in the hollows, and the slight haze which generally hangs about a hollow still further helps to deceive, and gives to a rough country the appearance of a flat plain. After about ten days of exploration work I was able to decide upon the most likely route and the steepest gradient necessary. This I judged should be 1 in 40, which would overcome the height to be climbed, and would be easy to work with a narrow-gauge railway.

Having made up my mind on these points, viz., the ruling gradient and the general direction of the route, I commenced a careful survey of the easiest alignment, the details of which were noted. The bush was cleared in front by a gang of eight natives, in a direction pointed out which would follow the most suitable ground which could be taken advantage of. The chainmen followed, and I brought up the rear with the level and compass. Levels were taken every 100 feet, with intermediates when necessary; the cross section of the ground was also noted, and the nature of the formation, whether earth or hard or soft rock. When two or more apparently suitable alignments presented themselves, and the question of which was best was doubtful, rough trial surveys were made, which determined the best to be adopted, and it was then gone over carefully.

The camp was shifted nearly every day, excepting Saturdays and Sundays. I had an intelligent native as headman, educated at the Livingstonia Mission. He was supplied with a watch, and when the camp was broken up after breakfast he was instructed to march in a given direction for half-an-hour or an hour, and fix the new site for the camp, the time he was to march being judged from the nature of the country through which the survey for that day would be conducted. He then got the tents re-erected, and saw that all the loads were safely brought up. By this system we generally found ourselves within a few minutes' walk from the camp at the close of our day's work, with everything in order, and the cooking of our dinner proceeding. After dinner the day's levels were reduced, and sometimes plotted, if there was any doubt as to what the route surveyed that day would involve. On Saturdays we generally took a walk to observe the surrounding country, or attended to correspondence. On Sundays we, of course, rested. This was the routine for four months, until Chiromo was reached, excepting for one instance at Zoa Falls, where the nature of the country was such that I was camped in one spot for eight days. So far easy ground had been found by the

valleys of the Luchenza, Tochila, and Ruo Rivers, but at the Falls of Zoa, on the Ruo River, there is a sudden alteration in the shape of the valley. Above the falls it is broad and open, with flat lands bordering the river, but at the falls the valley suddenly narrows to a gorge about 200 feet deep. It continues thus for about one and a half miles, when the valley broadens out again. The question was to get the most economical line located between the flat valley lands above the falls and those one and a half miles below. The sides of the gorge are very precipitous and seamed with deep watercourses, and the country inland from the river is broken up into deep valleys and high ridges. The whole place was covered over with dense clumps of bamboo, which very much increased the difficulty of determining the best route for the line. After much work, it was found that the most economical way to overcome the difficulty would be by introducing reversing stations, avoiding the very precipitous part of the gorge. This can be done by running down the side of one valley, which is at right angles to the main valley, and crossing its watercourse at a low level, backing out down the opposite side and round into the neighbouring and parallel valley, crossing its watercourse also at a low level. A second reversing station here will enable the train to proceed with the locomotive in front, and at the place where the line so developed by these zigzags has debouched again into the main valley it is just above flood level in the remaining short distance of the gorge, and the crossings of watercourses only require small bridges, instead of high viaducts. The flat bottom lands of the now widening valley are reached half-a-mile further on, and no further serious difficulties were encountered. This development of the line by zigzags makes the line one mile longer than by the direct route down the side of the gorge below the falls, but would effect a saving of £8,000 in construction by avoiding numerous viaducts. This was the only part of the route surveyed which involved any great difficulty in determining the most suitable alignment.

We arrived at Chiromo on the 1st of November, being four months and ten days from the date of starting. The distance from Blantyre to Chiromo by the route surveyed turned out to be $85\frac{1}{4}$ miles, and at 5 days in the week of survey work the average daily progress was, approximately, 1 mile, which, considering the nature of the country, was a very fair rate.

We spent a few days at Chiromo while I overhauled my note-

book, and made a short report of the route. The weather was very hot at this time, 105° in the shade every afternoon, and we had a very trying journey back by the plain at the foot of the Cholo hills. This part of the journey was not a pleasant one, the weather was so hot, the water so bad, and we were really getting run down after so much continuous outdoor work in such a relaxing climate. It was necessary that we should visit the Cholo district lying to the north of the Cholo hills, as it is an important district in coffee plantations, and the Directors of the African Lakes Corporation wished for a report on the question of taking the line that way. After examining the country there, I was able to report that a deviation from the route surveyed, embracing this district, was feasible. The gradients would be much steeper, but the route would possibly be shorter by 4 or 5 miles, and a watershed ridge might be followed which would effect a considerable saving in bridges. I recommended that it should be carefully surveyed the following season. We now returned to headquarters, as the rainy season was just approaching, when survey work would be inadvisable and camp life unhealthy.

In looking back on this survey expedition I cannot say that there were any very striking or remarkable incidents, though much that was new and interesting to me, and I might give you a retrospective sketch dealing with the most interesting subjects.

Everything went on very smoothly and without any adventures worth speaking of. In fact, I may say that I had more adventures on the survey for the West Highland Railway than I had on this survey in British Central Africa. I never saw nor heard a lion; we came across their fresh spoor occasionally, but we never were disturbed by them. Leopards were common, but we never saw one. They would prowl round the camp at night, attracted, no doubt, by the two goats we had. The general arrangement of the camp was—our two tents placed side by side; a suitable distance from these, and at intervals apart, the men built small sheds of branches and grass, so that our tents were quite surrounded. Before each shed a fire was kept burning, as well as one at each tent door, and, no doubt, these prevented us being disturbed by wild animals. Our route generally was close to, and running parallel with, the Rivers Luchenza and Tochila and Ruo, which all had a plentiful supply of good clear water. We could always get a cooling drink, even in the hottest day, by

having the water carried in a canvas bag. The rapid evaporation from the surface of the bag turned the water inside quite cold.

Native produce was rather scarce for some time, as the greater part of the route traversed was thinly populated, but there were evidences of there having been a very large population at one time. Native methods of cultivation are very wasteful; when they settle down in a place they clear the land round about most suitable for their gardens. These they cultivate for a few years until the soil becomes exhausted, when they will move off to fresh land, the old gardens turning into forest land again in ten years or so. The value of the wage paid to the ordinary native per month is 4s. The headman of a squad gets 6s. They are paid in calico, at the value of 3d. per yard. Two yards each were given them every month to buy food with. One man from each squad was deputed to purchase for his comrades, and they would travel very long distances to effect a good bargain; but sometimes they were unsuccessful in getting any food at all, and on these occasions the despondency of the whole camp was very great, and the headman held long consultations with us as to what should be done. At first we thought that the men deputed to buy had not made much effort, but it soon became apparent from their continued foodless state that there was really a scarcity. We had, therefore, to send to headquarters, a distance of 30 miles at that time, for supplies of maize and rice. This had to be done for a fortnight, until we came within reach of a village where food could be procured. The staple food of the natives consists of maize, beans, sweet potatoes, and the tubers of the arrowroot plant, called by the natives "kassava." Maize they always eat cooked, either roasted or boiled; beans they boil; sweet potatoes and arrowroot they eat either raw or cooked. They have also pumpkins during the rainy season, which they eat boiled. The maize is also ground by the women between the stones, or pounded with a heavy stick as a pestle and a hollowed-out round timber as a mortar. Millet is also grown, from which they make a kind of beer much esteemed by the natives. They make also a similar beer from maize. The grain is soaked in water, and allowed to ferment in large earthen pots, and afterwards boiled. This produces a thickish fluid like dirty milk in appearance, and with a sour taste and smoky flavour. I have met Europeans who said they liked it and found it refreshing, but that must have been when they were very thirsty and tired. Palm wine I also tasted in the Shiré valley, and thought

it like very flat and weak ginger beer. The natives are very fond of meat when they can get it, and the shooting of a buck or a hippopotamus was an occasion for great rejoicing, and put quite a new heart into our men. We shot three hippopotami altogether during the journey, two of these on the same occasion. The flesh was divided, and each man had a bundle of dried meat, which lasted him quite a long time. They ate it, after their first great feast of it, as a sort of relish to their ordinary food, but some bartered it for other foods with natives resident near our route.

The district was very poor in wild fruits; we only came across one clump of lemon trees, the fruit of which was very good and very welcome. I saw a few brambles, much like our own in appearance and flavour, only the fruit is pink when ripe. A kind of plum, about the size of a walnut, grows plentifully on a tree called the "msuka," which flourishes all over the hill country. The fruit has a dry, brittle skin, with a thin layer of sweet pulp, slightly astringent underneath; the greater part, however, consists of seeds. We came across a tamarind tree, a very large one, and covered with fruit, which we partook of, and were indisposed afterwards. A palm tree—the "hyphæne," I believe—grows plentifully in the lower valleys, and produces fruit about the size of a golf ball and about as nourishing. It has a thin outer covering of dry, slightly sweet substance, like brown sawdust in appearance; the remainder is a very hard, white kernel, like vegetable ivory. Very tasteless white figs are also common along the stream courses. You can imagine that one could not thrive if he had to depend on the wild fruits of that part of Africa. Of course, there are very many other fruit trees scattered over the country, but I am only mentioning what was commonly met with on my journey.

The botany of the country is very varied and interesting, but the wild fruits are certainly disappointing.

Garden fruit trees can be cultivated, and flourish well if they are carefully attended to. The loquat is becoming very plentiful from the gardens of the African Lakes Corporation at Mandala. Oranges, limes, and lemons grow well, also pomegranates, but insects bore into the fruit and spoil it. Delicious figs and nectarines are grown in Mandala gardens, and should become plentiful through time. There are one or two apple trees, but they bear very little fruit indeed. Pine apples can be grown in any quantity, but they are not remarkable for size or flavour

Mango trees have been introduced, and grow well, but they have not yet borne any fruit. The papau grows well, and the fruit is very wholesome, and useful for rendering tough meat tender. A few slices placed on the top of a large piece of tough beef, and allowed to remain one night, will render the meat quite tender by the morning.

The native produce which we ourselves commonly used was fowls, which are abundant and cheap—three to four for one shilling; corn flour, manufactured in the manner described, green maize, sweet potatoes, beans, tomatoes, and honey. Tomatoes were plentiful, small in size, with smooth skins, and very good to eat. Honey we always had, as there happened to be a native in our squad who had a special aptitude for discovering the hives and dealing with their contents. The hives were generally in a hollow tree, to which he applied smoke, and then enlarged the opening with an axe till he could reach the honeycomb with his hand, the bees meantime crawling all over him. He was seldom stung, and did not mind it when he was. The African honey bee is very similar in appearance and colour to our own garden bee, but slightly smaller.

The great curse of the country is the grass, which grows to a height of from five to eight feet, and sometimes higher if it has to struggle through bushes to reach the light. It grows in an extravagantly luxurious manner during the first two or three months of the rains. When the seeds are ripe they drop, and get caught by one's clothing. The seed is small, about the same length as, but thinner than, the common grass seed at home; one end of the seed is furnished with a remarkably fine, hard, sharp point, which is covered with tiny, hair-like barbs. The movement of the body acting on these barbs causes the seed to work its way through one's clothing to the skin, which the point pierces, causing much irritation. These seeds are also furnished at the opposite end from the barb with three or four delicate, wavy streamers, about three-quarters of an inch long. I have noticed that when the seeds have water dropped over them, these streamers begin to kick and wriggle in such an energetic way as to cause the seeds to move about. The reason for the barb and streamers became apparent when I observed this. When the rain comes and wets these dry seeds, the swelling of them, no doubt, causes the streamers to wriggle and work the barbed point into the soil, and thus the seed plants itself. One can

understand why this African grass has such a hold on the country, and why other grasses have no chance alongside of it, when it has developed such effectual means of propagating itself. Birds also, I should fancy, would not care to eat such seeds, and they are thus protected from enemies. These seeds will also stick to animals, and will be carried about until the animal feels the discomfort of the sharp point penetrating the skin, when it will scratch the seed off.

Another vegetable pest which annoyed us much is the mucuna bean, called by the natives "chiteze." It is a climbing plant, and the pods hang down in clusters from the trees and bushes. These pods are covered with a fine, hairy surface, which, when the bean is ripe, is easily shaken off, and when it comes in contact with the skin it creates a most horrible irritation. We suffered a great deal from it on the face, neck, and hands, as in cutting through the bush it was impossible to avoid it. The natives suffered more than we did, having more skin exposed. To remove the irritant they would wash themselves on the first opportunity, and scrape their skin with a stone.

There are also spear grasses with surprisingly sharp points, which cause an after irritation; also grasses which cut very badly, and from which the natives, with their naked feet, suffered a good deal. There are also plants which, when trod upon, give off a sickening odour like bad drains. Burrs also are very numerous, and stick to the clothes in masses, which impede one's movements. With all these things to annoy, you can imagine that survey work must be very trying. Of course, there are plants with pleasant odours, and spots free from grass and irritating beans, but one can't stop to enjoy these places.

I have not yet made mention of the bush fires, which are continually going on from the month of August until December. The air during that time is hardly ever clear from smoke, and only after a shower of rain, when for a few days the atmosphere is of sparkling clearness, and the landscape looks as if it had been well brushed and polished, in contrast to the dull leaden haze over everything previous to the shower. The natives start the fires themselves, in order to clear the ground of grass preparatory to planting their crops. In a way these fires are beneficial, as they clear the land of the dead grass, which, if allowed to lie and rot, would, no doubt, tend to the increase of malaria. On the other hand, they impoverish the land, at least land which has

any slope to speak of, as the ashes when the first heavy rains fall are swept away into the streams, although, no doubt, it enriches the Zambesi delta. Also they prevent a healthy growth in the trees, as the bark and young twigs get scorched, and this causes their scraggy growth. Where trees have succeeded in having a healthy growth, with plenty of twigs, and consequently thick foliage, it is noticeable that the grass underneath gets thin and low, and in places disappears altogether, for want of sunshine. As regards my own convenience, I found these bush fires rather useful for clearing the ground of grass when we found it was ready for burning. It was most interesting to notice how kites and hawks were found hovering over these fires just a few minutes after the men lit them. Also swallows and flycatchers were immediately on the scene—the former looking out for any small animals which might be driven out of their hiding-places or injured by the fire; the latter after the insects driven out of the grass and carried upwards with the draught caused by the flames. These fires do not travel quickly, the grass is too coarse, and a fire will die out very soon if a breeze is not blowing.

Both Mr. Baird and myself enjoyed very fair health during the survey. The natives also were free from any serious illness, although we had to do much doctoring for small ailments, imaginary or real. They doctored themselves to a great extent with roots, which they grubbed about for during their leisure time. The wearing of a charm, in the form of an anklet, armlet, or necklace of twisted calico, fibre, or elephant hair, with a leopard's claw or some other trifle attached, was considered a good medicine by some. One of the men fell over a high rock at the Falls of Zoa and bruised his leg badly. His companions partially buried him in sand in a reclining position, and kindled a fire over the injured part, which they kept burning for some time. This, no doubt, allayed the inflammation, as he was quite better next day.

At the end of the wet season, having finished all my plans and estimates, I started to make a survey of the Katunga-Blantyre road, in order to determine where improvements would be required for the traction engine sent out by the African Lakes Corporation. I had also instructions to report on the district of the Upper Shiré Valley past the Murchison Cataracts, as also to examine the country generally, so as to be in a position to make a general report on the question of various railway routes talked of. I had with me on this expedition Mr. Binnie, C.E., of Glasgow,

as an assistant. We found the road in a bad condition, with very steep gradients in places, and several deviations found to be absolutely necessary, were since carried out by Mr. Binnie, as already mentioned. We plotted these surveys at Katunga, and sent copies to the Directors, with reports, as the matter was urgent. We transformed one of our tents into a drawing office, and by erecting a rough shed of bamboo and grass over it we could work in comfort even in the hottest days.

We found the journey past the Murchison Cataracts a very interesting one. The district is, as a whole, rather rough and barren, and the soil is very scanty, with hummock of rock protruding all over the place. Wild animals, such as various species of antelope, baboons, and monkeys, were quite common, and the river in places swarms with hippopotami and crocodiles. The paths are mostly mere game tracks, leading to nowhere in particular, so that we had a good deal of trouble getting along and keeping our men together. It was a bad country to carry loads through, and one night the men with our beds did not make their appearance. We sent men back to look for them, and they all turned up next morning about seven o'clock.

We arrived at Matope all right, where there is a station of the African Lakes Corporation. We made several excursions from here to examine the surrounding district. Mr. Binnie then started to make a flying survey of the country back to Blantyre, making the Matope Blantyre road his base line, while I went up the river to Lake Nyasa in one of the river steamers of the African Lakes Corporation. I found the river above Mpimbi a splendid waterway, with the exception of one or two places, which could easily be improved by a little dredging. The general fall of the river is about 3 inches per mile, so that the current is very slack, except at one short stretch, which could be improved by removing a bar of stones. There is also a bar of sand at the effluence of the Shiré River from Lake Nyasa, which could be easily dredged. The country on each side of the river is quite flat for many miles from the banks, and railway construction would be easy; but considering how much more economically the river could be improved, so as to allow the lake steamers to come down to Mpimbi, than continuing the railway up to the lake, I judged that Mpimbi was the best point for the termination of the railway.

Lake Matombe, which is a widening out of the River Shiré about 15 miles below Lake Nyasa, is rather a remarkable place.

It is shallow, about 6 to 10 feet deep, and there is an enormous growth of reeds over a great extent of its area. It literally swarms with fish, especially mud fish. For a length of 10 miles in this lake there is a remarkable deposit of mud, of unknown depth, in which these fish live in enormous numbers. The mud is grey in colour, and just a little heavier than water. An analysis of it points to its being a vegetable deposit, probably from the growth of reeds in the lake itself. A gas is constantly bubbling from it, which is very inflammable, and which gave rise to an accident to an employee of the African Lakes Corporation quite recently. He had lit a match in the vicinity of a drain pipe on board the steamer, when there was an immediate explosion, burning his face and hands badly, and from the effects of which he was laid up for some time. Several small similar explosions had previously been observed, and a notice is now posted up to warn people of the danger.

Fort Johnston, on the river, about a mile from Lake Nyasa, is an important place. The African Lakes Corporation have a station there, where goods are transhipped from the river to the lake steamers. There is also a military and customs station of the Administration. The site has proved a very unhealthy one, owing to its lying on low, swampy land, and a large percentage of the Europeans have succumbed to malarial fever. It has recently been decided to remove this station to a place two miles further down the river, where there is an elevated tract of land, with a firm, dry subsoil, which is hoped will prove healthy. I examined the shores of the south end of Lake Nyasa, in view of the proposal to remove Fort Johnston there, but could not find a suitable site, owing to the swamps along the shore.

On a later visit to Fort Johnston, with Mr. Gibbs, the Manager of the African Lakes Corporation, I was up the lake as far as the abandoned station of the Livingstonia Mission near Cape Maclear. This station was given up as a residential one, as it proved very fatal to Europeans. It is a beautiful place, with a fine gravel, raised beach, but with rather bare, rocky hills immediately behind. This makes it very hot and relaxing during the day, with chilly winds at night, which was doubtless the cause of so much fatal sickness. The mission school still exists, and work is carried on by native teachers, periodical visits being made by the missionaries from the new site further north on the lake. Sailing on the lake is very pleasant in fine weather, as the scenery is wild and

mountainous, and the water is very clear and of a beautiful light indigo-blue colour. It is subject, however, to sudden and violent storms, which raise very heavy and dangerous waves.

Having rejoined Mr. Binnie, who meantime had been making good progress with the survey, we carried it on together into Blantyre. The results of the survey showed that a very easy railway route could be obtained between there and Mpimbi. From Blantyre a further report of our work was sent home, and we then proceeded to survey the alternative route of the Chromo-Blantyre section *viâ* the Cholo plantations. It turned out pretty much as I had expected from my general examination of the previous year. The route was shortened by 4½ miles, but the gradient had to be increased to 1 in 30 as against 1 in 40. This would necessitate a heavier permanent way, but a saving of £7,000 would be effected, owing to the shorter distance and the fact that the railway route would practically follow a watershed for 30 miles, and thus save many bridges, as all stream crossings would be avoided on that stretch.

I next made a final journey to Zomba and Liwonde, as it had been proposed to bring the railway that way, but I found that such a route would add very greatly to the cost of the line without having any compensating advantages.

The wet season was now coming on, and, all outdoor work being finished, we settled down again at headquarters and set ourselves in preparing plans, maps, estimates and reports, of our surveys.

The Europeans had, of course, been taking great interest in the railway question, and as there were proposals by other parties which did not meet their wishes, I was asked to lay the scheme of the African Lakes Corporation before a public meeting, to be called by the British Central Africa Chamber of Agriculture and Commerce. This was done, and the route *viâ* Cholo Coffee Plantations was agreed to be the best suited to the wants of the country, and the Foreign Office was strongly petitioned to aid in the matter, which it is to be hoped they will see the justice of doing.

The geology of the Shiré Highlands has not much variety—granite, gneiss, schists, and greenstone appear everywhere, and sometimes these seem to be all mixed up together. They are, as a rule, very much decomposed, especially the granite. In fact, the soil of the uplands (below the surface humus about one foot

thick) consists almost entirely of decomposed granite turned into red, ferruginous clay for the first four or five feet, and this gradually merges into rotten granite, with almost the same appearance as the hard rock. I have seen a pit 15 feet deep, and even at that depth the granite was quite soft, and could be worked quite easily with a pick. The general level of the Shiré Highlands Plateau is 3,000 to 4,000 feet above the sea. The country was doubtless at one time a very high table land of metamorphic rocks, with harder or less easily decomposed masses, which now stand up above the general level of the plateau as mountains, 6,000 to 9,000 feet above the sea. Probably, too, all the less ancient formations were at one time on the top of this, including the coal measures, as coal is found in the country between the Shiré and Zambesi Rivers, about 50 miles from the south edge of the Shiré Highlands Plateau. All the streams from the Shiré Highlands flow over a very hard bed of the rocks mentioned, in a series of shallow pools and rapids, with occasional waterfalls. This is their character until they reach the valley of the Lower Shiré, where, by their agency, the alluvial deposits have been formed.

Iron ore is very abundant throughout the country, both magnetic and hematite, the latter very much decomposed. Large blocks of the former exist, and the compass is in places quite useless for taking bearings with. Native smiths smelt the ore in a dome-shaped clay furnace fired with charcoal. The bellows consist of a skin bag attached to a clay nozzle fixed near the bottom of the furnace. The top of the bag has an opening, which can be closed by drawing the edges together with the two hands. By alternately raising the bag with the opening free, and pressing it down with the opening closed, air is forced into the furnace and blows the charcoal into a white heat, and the iron ore mixed with it is smelted. The iron thus obtained is worked into spear and arrow points, and also hoes for agricultural purposes. The tools used by the blacksmith are a rough iron hammer and pincers.

Mica is present everywhere. Quartz is abundant, but I found no traces of gold. Traces of this precious metal have been found there, not, however, such as to lead one to expect that it existed in paying quantities; but the country has never been thoroughly prospected. Limestone is found a few miles north of Blantyre. Graphite exists in small quantities.

The climate during the dry months, from July to November, is very pleasant. The mornings and evenings are cool and fresh, although the sun during the mid-day hours is very powerful. The shade temperature during the day ranges from 75° to 98°, and during the night the temperature falls to about 65°. This refers to the uplands, but in the lower valleys, among rocks, the heat is sometimes almost unbearable. The rains begin in December and last until April. The day temperature then may range from 75° to 95°, and the night temperature from 65° to 80°. From April to June is the cold season, the day temperature of which never rises above 75°, while the night temperature may fall as low as 40°. The annual rainfall ranges from 60 to 75 inches. The prevailing wind from April till December is south-east, and during the rest of the year (the wet season) the general direction of the wind is from the north-east. The rain comes in heavy showers, usually accompanied by thunder and lightning and strong cyclonic winds, so that locally the wind may blow from any point of the compass, although its general course is from the north-east. It does not rain every day during the rains; there may be four or five days in succession quite dry. I have noticed there are periods of perhaps fourteen days in succession during which there will be showers in the forenoons with fine afternoons, followed by a similar period of dry forenoons and showery afternoons. It does not rain so frequently at night as it does during the day.

Coffee planting is now an established industry in the Shiré Highlands. It is expected that about 500 tons will be exported this year, the average value of which will perhaps be £80 to £90 per ton. The plant is of the Mocha variety, and the parent of all the present trees, covering an area of about 3,000 acres, was one of three small plants, sent out by the Churches of Scotland Mission, which survived the journey from the Edinburgh Botanic Gardens to Blantyre, and was planted in the mission garden there. About 100 Europeans are now engaged in this industry.

The cultivation of the sausevieria fibre has also been started. It grows in dry, stony ground all over the country, but especially on the rough, rocky slopes in the valleys. The fibre extracted from it is very fine and strong, and fetches a good price. It would be a valuable adjunct to coffee plantations, as it can be grown on otherwise useless land. Also the landolpia rubber vine grows well and yields a good supply of rubber, and could be grown in

any forest land not required or suitable for coffee. Coffee planters ought to turn their attention to these auxiliaries more than they do.

It cannot be said that British Central Africa is a healthy place, but, with a sound constitution and the exercise of care, it is not dangerously unhealthy. The death-rate is about 8 per cent. per annum among the Europeans, but there are so many men who go into the country who should not, and who live careless lives, that statistics make the country appear worse than it is. The death-rate among the employees of the African Lakes Corporation was at the rate of 3 out of 70, about 4·3 per cent. last year, but only two of these died of a climatic disease. Malarial fever, in its simple form, is common. Dysentery, also, is not uncommon, but fatal cases are rare. It is the dreaded blackwater, or hæmaturic, fever from which so many die. Every one has more or less a nervous dread of this form of malarial fever, and it certainly is alarming. About 75 per cent. of the cases prove fatal. Fatal cases of sunstroke are uncommon. In fact, I may say that, but for malaria, the country would be a delightfully healthy one to live in, as there are hardly any other diseases from which Europeans suffer. Speaking for myself, I was blessed with fairly good health during the two years I was in the country. I had occasionally low fever, but was never confined to bed with it. I took a dose of quinine, 5 or 10 grains, nearly every day, though whether that is a good thing to do or not is a debatable point. I was careful always to protect myself from the sun with a helmet and sun umbrella. I wore woollen underclothing and light tweeds, and thus avoided the danger of catching chills, which one is so apt to do in linen or cotton clothing. A chill always brings on fever, and I do not think the majority of the Europeans there clothe themselves sufficiently to protect themselves against chills. Of course, people will take fever, however careful they are, but careless people are certainly much more liable, and I know I would have had bad attacks of fever if I had not taken great care of myself.

In the foregoing pages I have collected a few facts which strike me at this time, and which compose a rather hotch-potch article. If I have said anything which is interesting or new to you, the pleasure I have in recording these before this Society will be very greatly increased. Many books have been written on this part of Africa, and to those who wish to know more about this part

of Africa I can only refer them to the books written by Mr. Scott Elliott, Sir Harry Johnston, the late Professor Henry Drummond, the late Messrs. Monteith Fotheringham and John Buchanan, as well as the books of travel of Dr. Livingstone and James Thomson.

VI.—*The Indian Mints.* By William Warrand Carlile, M.A.

[Read before the Economic Section of the Glasgow Philosophical Society on 2nd March, 1898.]

It is now a little more than four and a-half years since the Indian Mints were closed to the free coinage of silver, and it cannot be denied that the object of the measure, in putting a stop to the continuous fall in the exchange, has been, to a very large extent indeed, achieved. To-day the value of the rupee is nearly 1s. 4d., while its average value for 1891-92 was below 1s. 3d., and this though in the interim silver has fallen by another 33 per cent. The critics of the measure, however, will tell us, probably, that the present value of the rupee is something altogether exceptional, that we shall soon see the exchange tumble down again to 1s., and, as likely as not, stop there. Prophecy is always hazardous. At the same time, one may be permitted to point out what facts there are that make for a contrary conclusion. They are, briefly, the following:—Though during the earlier part of the period that followed the closing of the mints the rupee fell heavily, it took an upward turn in 1895. Exchange had been estimated in the budget of that year as likely to average about 1s. 1d.; it was found, by March, 1896, that it had actually averaged over 1s. 1½d. Again, in 1896, the estimate was 1s. 1¾d.; but in March, 1897, it was found that 1s. 2½d. had been realised. We shall know in a few weeks what the result for the present year has been.* It is quite beyond question, however, that it will again show a conspicuous improvement on last. It seems thus mathematically certain that time is all that is necessary to bring up the value of the rupee to 1s. 4d.—the figure fixed when the mints were closed; though, at the same time, there is good reason to believe that many thousands, if not millions, may yet be lost by our failing to forestall, by administrative action, the operation of natural causes. It is worthy of note that the course of events has most literally fulfilled

* The result is 1s. 3⅜d.

the predictions made with regard to it. When the mints were closed, it was urged by hostile critics that the measure would be rendered ineffective by the rupees that would come out of the hoards, or that would come back to the country from lands outside India, as soon as the coin acquired a scarcity value. To this the Finance Minister replied that whatever trouble was likely to be experienced from that cause would be encountered at the outset, and that the longer the new system was maintained the less would this trouble be felt, that ordinary wear and tear would use up several crores of rupees per annum; so that there was every reason to expect that the simple stoppage of fresh coinage would prove perfectly effective in limiting their quantity and in raising their value. In the face of the facts above given, can any sane human being deny that it has done so? Surely, too, the presumption is overwhelmingly strong that it will continue progressively to do so in the future. The Indian Government, at any rate, feel confidently assured that it will. "We believe," they say, in their famous despatch of September last, "that our difficulties are now nearly over, and that we shall, in the near future, succeed in establishing a stable exchange at 1s. 4d. the rupee, by continuing the policy initiated in 1893."

The trend of events thus seems to be in favour of the probability of the establishment sometime or other of a stable exchange at 1s. 4d. There is, at the same time, one aspect of the situation that may well give the Indian Government grave cause for anxiety—that is, the present high rate of interest, and the wrong-headed agitation with which it is accompanied. High interest is always due to a scarcity of capital; and to imagine that it could be cured by a measure like the opening of the mints, which would only increase the currency without in the least increasing the capital in the country, is nothing but the stalest of fallacies. If it is asked, how is money to be made more plentiful in India, there can be but one answer. That can only be done by making the tide of English capital set towards the country, instead of setting away from it as at present; and that end again can be achieved in no other manner than by bringing about an increase of confidence on the part of the public here in the future stability of the exchange. The question as to the best method of effecting that end I propose to deal with later on. In the meantime it may be said that that part of the community in India who urge the reopening of the mints are themselves in very large

measure to blame for the scarcity of money. Who, indeed, will send his money to a country where an important section of the Press is urging the adoption of a course that would make it impossible to get back capital invested without a loss amounting, perhaps, to 30 or 40 per cent.? Only five months ago the Imperial Government itself was contributing towards this impairment of confidence by parleying with the American silverites about the reopening of the mints, and by thus giving rise in the commercial world to the apprehension that any day all that had been done towards raising the value of the rupee might be undone again, and that the Indian currency might again be allowed to follow the fortunes of silver to whatever limitless depths yet lay ahead of the metal. The present monetary stringency in India may indeed be regarded as a *damnosa hereditas* from the events of September last. It is, however, quite incredible that such a measure could be seriously contemplated by any party when they came to deal with it at close quarters. Mr. Sauerbeck, the eminent statistician, the other day, in a letter to the *Times*, tells us that Russia took last year about a third of the world's output of silver with which to replace her one and three rouble notes. This year she will take another similar amount, and then she will want no more. Another very heavy fall in the value of the metal seems thus sooner or later to be impending. It is now at about 10d. the rupee; we may shortly see it at 6d. In such circumstances the reopening of the mints would mean nothing else but bankruptcy for our Indian empire.

As to the high rates of interest now ruling in Bombay and Calcutta, we should, of course, greatly exaggerate the character of the monetary situation there if we looked upon them as meaning the same thing as similar rates ruling at home would mean. The normal rate of interest, as determined by the normal rate of profit, is, of course, much higher in India than it is here. 11 and 12 per cent. would be panic rates in England; in India they appear to be consistent with a degree of general prosperity, as evidenced by the returns from railway traffic, from savings banks, and from post office business, which cannot but be regarded as amazing in view of the appalling experience which a great portion of the country has just passed through. At the same time, such rates are beyond question a serious evil, and an evil that, it seems to me, it would have been possible to avoid.

If there was, as it now appears that there was, so obvious a

resource open for stopping the fall in exchange, with all its attendant dangers and mischiefs, as that of merely declining to coin silver into rupees for anybody and everybody who thought fit to bring it to be coined, the question presents itself, why did any Government hesitate to adopt it? why, indeed, was it not adopted long before? and this, I think, is the question that posterity will ask, and, very probably, will ask with open-eyed astonishment. We heard a good deal at the time of the closing of the mints, and from very authoritative quarters, about the course of hazardous experiment that was being entered on by the Government in permitting the cessation of the free coinage of silver; but surely the truth lies rather with the view taken by Mr. Douglas, in his pamphlet on the Indian currency, that the Imperial Government had been engaged on a course of most hazardous, and, indeed, of most disastrous experiment during the previous twenty years, in insisting, in spite of the remonstrances of the Indian authorities, that the mints should be kept open, while all the self-governing states in Europe had closed theirs. The bimetallists are, in the main, right, it seems to me, in their contention that it was the legislative changes of 1872 and 1873, rather than a change in the conditions of the production of silver and gold, that led to the great fall in the value of the former metal. It does not represent the case at all accurately, however, to assert that it was the French bimetallic law that maintained the ratio. What maintained it was the fact that, while England was a gold country, and the Latin Union was bimetallic, Germany, and practically the rest of the world, except the United States, was silver-using. It was possible, in these circumstances, for France to hold the balance between the two metals; and, no doubt, her law did something to maintain the more perfect fixity of a ratio that would in any case have remained approximately steady. Occasionally, in the sixties, silver went to a premium as compared with gold; and it is unnecessary to point out that a law which fixed the price of the metal at something under 5s. 1d. per ounce could not have had the effect of sending it up to 5s. 2d. Its rise was due to the fact that the demand for silver for export to countries that looked on it as money, and where, consequently, one needed silver in order to do any business, was greater, at the time, than the demand for gold for export to countries that looked on gold as money, and where gold was needed to do business. In these circumstances, the circumstances that ruled before 1873 to keep the Indian mints open to

the free coinage of silver, was a step no more unwise or hazardous than it is for us at present to keep our mints open to the free coinage of gold. Once, however, that Germany demonetized silver and began to put it on the market, the situation was altogether altered. One after another all the nations of Europe grasped the fact that it was altered, and closed their mints to the metal. To keep mints open to gold or to silver while natural causes were maintaining it on a parity with gold was only in name fixing a price for the gold or the silver that was coined. The price of £3 17s. 10½d. that we pay for gold, it has often been explained, means no more than this, that 40 pounds troy of gold are coined into 1,869 sovereigns. Once the parity between silver and gold was broken, however, keeping the mints open to it meant something very different. It meant that the country that did this was sustaining the value of an import against itself. Supposing the market value of American wheat was, at any moment, 3s. per bushel, and that the English Government were to announce to the world that it was a buyer of all that was offered at 5s. per bushel, it would surely be guilty of an incredible absurdity. It would have done nothing more absurd, however, than it actually did in forcing up, against itself, the value of American silver, by keeping the Indian mints open. To-day, now that silver has fallen to its natural level, it has a purchasing power over Indian commodities of a little over 2s. per ounce. For every ounce of it that is imported into India, only about 2s. worth of Indian commodities have to be exported. During several years, largely owing to the action of the rulers of India themselves, the purchasing power of silver over Indian commodities was maintained at something like double that figure. For every ounce of it then imported, from 3s. to 5s. worth of Indian commodities had to be exported. Between 1873 and the closing of the mints, Sir David Barbour estimated that some 800,000,000 rupees had been lost by the Government. No doubt the whole of this sum did not represent a dead loss to the Indian community generally. Some part of what the Government, as landlord, lost, the ryot, as tenant, gained. The ryot, however, it must be remembered, was receiving his gains in a continually depreciating medium. If he was something to the good at first, owing to the fact that a smaller portion of his produce paid his rent than would have paid it if there had been no fall in the exchange, he lost heavily afterwards by the depreciation that yet

awaited the rupees that he laid aside as savings. The net loss to the Indian community, as a whole, by the policy adopted, or rather by the failure to adopt earlier a policy that had to be adopted eventually, was unquestionably something portentous. We may, perhaps, come at some rough guess as to its amount if we consider what the net import of silver into India was between the date of the German demonetization and the closing of the mints. It amounted to 1,500,000,000 of rupees. Over 90 per cent. of the total import was coined. On the silver imported during the earlier years of the period, the loss would be between 8d. and 9d. per rupee. On that imported in 1892 it would be about 1½d. If we take the mean between these two figures, we have an average loss of about 5d. per rupee, or something over £31,000,000 sterling altogether. It is, of course, a matter of speculation how much of this loss was preventable. I am inclined to think that the whole of it was. Silver has fallen, in all, from about 5s. per ounce to a little over 2s. Suppose the mints had been closed in 1873, there is every reason to believe that the fall as far as 3s. 2d., the price in 1893, would have taken place at once, and if it had, every shilling of this £31,000,000 would have been saved to India. When the imposition of an import duty on silver was suggested, it was vetoed on the ground that silver was the raw material of an industry which it was desirable to foster. Surely, however, if it were undesirable that the Government should artificially raise the price of this material for its own benefit, it was doubly undesirable to raise it for the benefit of foreigners.

If the Imperial Government desired to secure for India the inestimable benefits of a depreciating currency, it would have been ten times better for it to have set its printing presses to work, and to have turned out inconvertible paper by the million, rather than to have kept the mints open to the depreciating foreign silver. The inconvertible paper would have given all the stimulus to production that it was maintained the depreciating rupee gave. It would, no doubt, like the depreciating rupee, have disorganised business, have altered the basis of contracts, have despoiled the wage earner, and have prevented capital from coming into the country, but, at any rate, the paper money would have originated in India itself, and would not have drained the resources of the country for the profit of foreigners.

Who were then the gainers by India's loss?—for certainly the wealth that she lost did not vanish into space. We know that

Germany, when she demonetized silver, had some £46,000,000 of it to get rid of, and that she got rid of about £28,000,000 at very excellent prices indeed, a great deal of it at very little under 5s. per ounce, and none of it below 4s. 2d. That she was able to do this was, in large measure, due to the fact that the Indian mints were kept open; and thus no small proportion of India's millions found their road straight away into the coffers of the Imperial Bank at Berlin. The bulk of the balance, no doubt, gravitated, in the end, towards the pockets of American producers of the metal. Without having suffered a Sedan, India, and the Empire through India, was compelled to hand over to the foreigner a sum that was the equivalent of a very respectable war indemnity. So much for the system of managing Indian affairs in the interests of the human race, and in accordance with the dictates of scholastic theory.

Sir Robert Giffen, in a recent number of the *Nineteenth Century*, deals with the subject of the Indian mints. While he does not venture to maintain that they ought now to be reopened, he, with a curious inconsistency, warmly attacks the course taken in closing them. He uses, indeed, some very strong expressions as to what he regards as the injustice done to the ryot in having 50 per cent., added to his rent, as he puts it, by that measure. As the value of the rupee has not risen more than 6 per cent. since 1893, this view assumes that the ryot had a vested interest in its progressive depreciation. We are told, too, that the closing of the mints was a step at variance with the traditions of the English monetary system, and based on no sound economic principles. As to the assertion that the measure was out of accord with English traditions, nothing is more certain than this, that the one thing which the English people have never tolerated any longer than they could help it has been a shifting of the par of their exchange with other countries, to their disadvantage, owing to currency causes. Is it to be imagined for a moment that, if England had been in the place of France when Germany demonetized silver, England would have acted otherwise than as France did? Self-interest is a great sharpener of the wits in such matters. If her own immediate interests had been directly concerned in the case of the Indian mints, the theorists, whatever their hue, would have preached to her in vain about either the "appreciation of gold," or the inviolable principle of *laisser faire*. When, in 1695, it was found that every £1,000 sent abroad to aid in

William's wars was, owing to the state of the exchange, converted into about £700 by the time it reached Holland, our ancestors, at first, expressed great indignation, attributing their loss to the machinations of the Dutch. They set about, however, to search for the cause. They found it in the state of their own coinage, and promptly proceeded to remedy it. In 1819, again, in spite of the Birmingham inflationists, who would have it that it was not the bank notes that had depreciated, but gold that had risen in value, they resumed specie payments on the old basis, and thus again rectified their exchange. In both instances much was obscure to them that is plain enough to us. They had to find out for themselves, and to formulate the principles that underlay the subject. In all that we have entered into their labours. There was one thing, however, that, from the first, stood out clear for them beyond all question, that was the maxim that English money should always be kept in such a state as to be as good as any other money in the world; that, when sent abroad, or converted into the medium that had to be sent abroad, it should never have to be sent or converted at a loss. As to accordance with sound economic principles, it would be strange, indeed, if the following out of such principles should lead the state that followed them out into a condition in which the amount of its import of any commodity would depend not on its own requirements, but on the exigencies of the sellers, of those whose aim it was to get rid of the commodity. Yet that was precisely what happened to India with regard to silver while her mints were kept open. The less that she or anyone else wanted of silver, the more was she forced to take. How would such a state of things accord with Ricardo's doctrine, which is certainly as well established as any in economics, that, under a sound monetary system, imports and exports would follow the same course as under a *regime* of barter.

In connection with this Indian problem we know that monetary history has been ransacked for examples calculated to assist in indicating the best method of transition from a silver to a gold standard. Has anyone drawn attention to the circumstances that attended the transition in England itself? Nothing is more certain than that we had the silver standard in England 200 years ago, and that now we have the gold. When and how did the change take place, and is there anything in its history that will be useful to us in our present circumstances? The change was effected in England—the bimetallists, to a man, will answer,

and many monometallists as well—by the Act of 1816; but the answer will not bear a moment's examination. Let anyone take the most cursory glance at the state of monetary matters in Adam Smith's day, and he will find that there was not then in existence anything that even remotely corresponds to our conception of a silver standard. The wonderful thing, indeed, is that, in spite of the bimetallism that existed by statute, the state of things that existed in practice, and that had existed during nearly the whole of the eighteenth century, was precisely similar to that which exists among ourselves by statute at the present moment. Adam Smith speaks of gold as holding up the value of the silver coin just as one might speak of the sovereign as holding up the value of the shillings and half-crowns now. The mint price of gold had remained for a long period steady at £3 17s. 10½d., and the foreign exchanges had, for very many years, been entirely unaffected by the state of the silver coinage, and had varied only in accordance with the condition of the gold and of the balance of trade. If anyone contends that all this does not amount to the existence of a gold standard, we need not bandy words with him. It is, at any rate, the state of things that the Government are now aiming at establishing in India as a gold standard, and with which, if they could establish it, every one would be completely satisfied. If we had the silver held up in value effectually by the gold, and the exchanges henceforth unaffected by anything but the balance of trade, we should then have in India all the gold standard that anyone wants or aims at. If we go back, however, eighty years earlier in English history than the publication of the "Wealth of Nations," we find a wholly different state of things in existence. Then the guinea went up and down in value as the rupee does now; and then, just in proportion as the silver was depreciated, did the foreign exchanges turn against us. It is plainly, then, somewhere within this period that we have to look for the true transition from silver to gold in England. According to Lord Liverpool, the great change came about immediately after the guinea had been made legal tender at a fixed rate of 21s., in 1717. I think there is evidence that, in truth, it came about a few years earlier, when the order was issued that the guinea should be accepted in payment of taxes at a fixed rate something above 21s. in the first instance. That, however, need not occupy us at present. How precisely it did come about is a question of very great interest, both speculative and practical.

We had, at the end of the seventeenth century, silver the undoubted standard, but with the mints open to both metals; we jump a score of years, and then we find that gold is the standard, and that silver has become a subsidiary coin; yet, as far as statutes go, nothing whatever is altered. Both metals are still unlimited legal tender, and the mints are still open to the free coinage of both. Absolutely all that has been changed in the interim is that a ratio of exchange between the two has been fixed. The current explanation of the phenomenon, in so far as it has been recognised as needing explanation, is a rough and ready one. Gold, we are told, being overvalued at the mint, ousted silver as the currency of the country, by virtue of Gresham's Law; people thenceforward came to measure values in gold; and in the end—a century later—gold was adopted as the legal standard. But, to begin with, is there any truth in the assertion that gold ever ousted silver as the ordinary currency of England? Does it not stand to reason, on the contrary, that, with a state of things in existence socially in which the working man was drawing wages of ten shillings a week or under it, and was being paid weekly, the currency must, to a very great extent indeed, have continued to consist of silver? If we want specific contemporary evidence on the subject, however, we have it from Harris. Writing in 1757, he tells us that, in his time, "the great inland commerce of the country was chiefly carried on by silver"—that "labourers, handy craftsmen, and manufacturers of all sorts" were paid their wages in that metal. What happened was:—first, that silver bullion being overrated as compared with gold, practically no fresh silver was brought to the mints to be coined. The mints were thus closed to silver as effectually as if they had been closed by statute. Secondly, all the heavier silver coins were picked out, melted down, and exported. What were left, however, must have been no insignificant quantity, if they were sufficient to carry on most of the inland commerce of the country They were, however, sufficiently depreciated in value by loss of weight, to be at any rate not more valuable intrinsically than they were nominally, otherwise they would have gone to the melting pot. As time went on, they continued to suffer from wear and tear, till, by the middle of the century, they had lost from a third to a half of their original weight, and were consequently very greatly overrated as compared with the gold that was circulating alongside of them. Why, then, was not this gold melted down and exported, as, according to Gresham's Law, it ought to have been?

You had there two kinds of money circulating side by side, and both unlimited legal tender. In such circumstances Gresham's Law tells us that the overrated money must infallibly oust the underrated from circulation. On the contrary here, however, we see the overrated money, instead of ousting the underrated, subsiding into the position of a representative money alongside of it. The reason plainly enough was that the seller and creditor class would not accept the silver coin except in small payments, and therefore no one thought of tendering it to them in large payments. The weak point of Gresham's Law is that it assumes that this class will always remain completely passive, and accept whatever is given them without demur. We often think of the device of fixing the nominal value of the subsidiary coin at something a little above its metallic value, in order to prevent its export, if silver should rise in the market, as an ingenious suggestion of Lord Liverpool's. The truth was that nature had done this already long before Lord Liverpool's day. He had merely to copy the system that nature had established. The only true sphere of legislation in monetary matters indeed appears to be thus to follow nature.

The failure of Gresham's Law to operate in this instance points plainly enough to the conclusion that the law itself is only true in certain circumstances and within strict limitations, and that, stated in its ordinary rigid and absolute form, it is no better than a fallacy. Mill thus states it, for instance, when he says that "Where there are two legal standards, that one of the metals will always be the standard of which the real has fallen below the rated value." If this were true, if it were true that Gresham's Law determined necessarily not only the currency, but the standard of value in a country, then we should surely have found that the metal which was steadily on the down grade since early in the middle ages, and was consequently continually falling below its rated value, would have in the end definitely supplanted the other as the general standard of the world. The very contrary, we know, has happened. Gold has almost always in modern history been rising in value as compared with silver, and now it is gold, and not silver, that has become the universal standard. From the point of view of pure theory, too, the doctrine that the poorer money always ousts the better has, as observed, a manifest weak point. It involves the assumption that it lies absolutely and entirely with the debtor class, the class who have payments to make, to say what the money of a country shall be. That

this should be so is contrary to all experience. It is the creditor class, the class who have payments to receive, who in such matters are in the end always masters of the situation, and for this there is a very obvious reason, viz., that the money in which payments for goods are to be made, or in which money lent is to be repaid, is ordinarily determined on before the creditor becomes a creditor at all, and while the goods are still in his warehouse, or the money is still in his till.*

If this is so, however, it may be asked, how then does Gresham's Law ever come into operation at all? To answer that question, and to get any grasp of the true theory of money generally, it is necessary to advert to the distinction which was drawn by Adam Smith between "the two branches of money," as he called them, and which was dwelt on somewhat more in detail by Tooke, one of the very foremost names, to my thinking, in modern economics, but which appears to have been lost sight of, more than it ought to have been, in recent discussions. "The circulation of every country," says Adam Smith, "may be considered as divided into two branches—the circulation of the dealers with one another, and the circulation between the dealers and the consumers. . . . The circulation between the dealers," he goes on to say, "as it is carried on by wholesale, requires generally a pretty large sum for each particular transaction; that between the dealers and the consumers, on the contrary, as it is generally carried on by retail, frequently requires but very small ones." There is thus a difference between large and small payments that is, in the main, not only one of degree, but also of kind. The one are the payments of trade and production, the other the payments of consumption, and this difference is of prime importance in connection with the theory of the standard of value. It is in regard to retail payments alone that Gresham's Law operates, and the reason is obvious. The shopkeeper who accepts currency for his wares thinks, and is ordinarily justified in thinking, that, whether the money that he takes is liable to depreciation or not, the chances are greatly against its so depreciating while it is in his possession as to affect his interests. He has, too, to face the competition of other shopkeepers whose goods are for sale at the same price as his own. In such circumstances it is the buyers'

* *cf.* Mr. Edward Atkinson's answer to question 33,176.—Evidence given before the Commission on Agricultural Depression.

money, whatever it is, that tends to become the general medium of exchange, so far as the transactions to which it is applicable go. With the payments of wholesale trade the case is altogether different. Being large sums, their intrinsic value comes to be all important to those who have to accept them. A great many of such payments are the payments of foreign trade, and the money to be paid must, of course, in that case have a value not in one country only, but in any part of the world, otherwise the vendor stands to lose directly and immediately by taking it. Even when that is not so, the man who receives a large sum knows that he may have to keep it by him for a long time, and therefore will not accept a description of money that is liable to fall in value, unless indeed he compensates himself by asking more of it than he would accept of the sound money. Thus, whatever sort of money it is that actually changes hands, the bargain is sure to be made in the most trustworthy medium. It is in the wholesale trade, however, that the prices of commodities are all really fixed. The retail seller, as a rule, merely takes the prices as they reach him, and adds a uniform percentage; and thus the medium of wholesale trade, being that in which values are determined, cannot fail to become the true standard of value. The main channel which connects the two branches of money, the retail and the wholesale, is to be found in the weekly payments of wages to the labourers engaged in production, and, if there are two sorts of money in a country, a worse and a better, the wage-earner is quite certain to be paid in the worse. It is, no doubt, greatly against his (the wage-earner's) interests in the long run, and as a body, to accept the worse, but it does not appear to be so in regard to any individual transaction. The class indeed, as a rule, in any state, are ordinarily found to be in favour of "cheap money," as they call it, unless it chance that they have had a bitter experience of its working, and have become intelligent enough to connect cause and effect. The wage-earner, at any rate, usually accepts the worse money without demur, and through his expenditure it is that it finds its way through all the retail circulation.

Perceiving this, and holding, most justly, that the very first duty of the rulers of a state is to see to it that there never shall be two sorts of money—a worse and a better—circulating together in the country, Locke, and after him Harris, laid it down that silver was the only suitable standard of value, as it certainly was the only

medium in which both large and small payments could be made. When Locke wrote, however, the possibility of keeping even a token coinage on a parity with gold was something as yet undiscovered in the world. In view of this discovery, which has of late years received a very ample extension, Locke's principle, while being firmly maintained in substance, may be varied in form. The doctrine which, in the light of modern experience, he himself would, no doubt, have laid down would be this—that in any country the medium of small payments must either be made to consist of the same substance as that of large, or else must always be kept convertible into it at a fixed rate and without the smallest loss. If that end is secured the wage-earner is just as efficiently protected as if all the money of the country consisted of the very same substance.

This view of monetary theory leads to conclusions which have an intimate practical bearing on the subject under consideration, and these I will endeavour briefly to set forth. It is important, in the first place, to recognise that the true historical order in changes of monetary systems is this—that the standard changes first, then the currency. The usual theory reverses this order. Under the operation of Gresham's Law, we are told, a change of currency comes about, and thereupon, in time, follows a change of standard. This theory can, no doubt, claim high authority in its support, but what, I should like to know, would its adherents make of the case of a country like Java, where the standard is universally acknowledged to have changed, but where the currency has remained absolutely without any change whatever. Such a case surely makes it clear, at any rate, that the standard can change antecedently to a change of currency, or, indeed, altogether without it. Java, with its mother country, Holland, has been on a gold basis for more than twenty years past, yet this is the account which a Mr. Kensington, an Anglo-Indian gentleman who visited the island in 1892, gives of his experiences there. He had been told that, though the country was a gold standard country, the people there neither knew nor saw anything of gold, so, from curiosity, he obtained a few ten-guilder gold pieces, the legal tender of the island, and proceeded to experiment with them. He found that they were accepted at railway stations without demur; that they were accepted, but with exclamations of astonishment, at a Dutch shop in the principal street of Batavia; and that they were altogether declined at a bazaar 200 miles up country.

It seemed clear to him that "the great mass of the people neither knew nor felt the existence of the gold standard in any way." Was the gold standard in Java, therefore, nominal and meaningless? Assuredly it was not. The whole character, not only of the internal and external trade, but of the internal currency, was revolutionised by it, though the majority of the people who used it were quite unaware of the fact. It saved the country from the trouble, the anxiety and the disastrous loss, which the depreciating rupee entailed on India, while the peasant and the wage-earner could lay aside their savings in the ordinary currency with the same security against its value becoming a vanishing quantity as the labourer in Sussex or Middlesex, who lays aside his savings in sovereigns, is entitled to feel.

We see what a subtle thing, then, the standard of value is. Anyone can tell us what the currency of a country is. He can bring us specimens of it, indeed, in his hand; but if we ask what the standard is, it is often a case of *quot homines tot sententiæ.* Yet it is of the utmost importance to the scientific treatment of the subject to discover a test by the application of which we can say definitely whether in such and such a country, and at such and such a date, gold was or was not the standard of value. If we ask on what ground do we feel justified in asserting that Java possesses the gold standard now, though her people know nothing about it, and use the same currency as they did when the country had the silver standard, we can certainly answer that we regard the standard as being gold, because the silver currency is convertible into gold (though only directly convertible for the purposes of external trade), and because her exchanges are no longer affected by anything but gold and the trade balance. It may then safely be laid down that, when the currency of a country is convertible into gold at a fixed rate, and when silver no longer affects its exchanges, then it has a gold standard. If we go on from this, however, to argue that the converse also holds good—that whenever the exchanges of a country are affected by fluctuations in the value of the internal currency which is something else than gold, that country has not a gold standard—then we are met by a difficulty. During the Bank Restriction we know that people came to measure values in bank notes, and that both the market price of gold and the foreign exchanges went up and down in accordance with the quantity of notes out, and with the credit they enjoyed; yet who doubts now that gold was in truth the standard of England at the

time? Who gives in his adhesion now to what Fox described as the "fantastic doctrine" that the printed promises to pay gold were the standard by which the value of gold itself could be measured? We have thus to seek for some other criterion. The only possible one is to be found in the answer to the question whether the money of the country's wholesale and foreign trade is gold or not.* If that has to be answered in the affirmative, then the customary standard of the country must be regarded as being already gold, and we may reckon, sooner or later, on finding a demand arise for legislation to bring the legal standard into conformity with it. Harris, in the middle of the eighteenth century, stoutly maintained that the standard of England was then still silver, and not gold. He admitted that the standard of the merchants was gold, but contended that that had nothing to do with the matter. The course of history has shown, however, that the legal standard of England had very soon afterwards to be made to conform itself to the standard of the merchants—that is, to what had already become the standard of wholesale trade. The first business of the legislator in monetary matters is to ascertain what is the customary standard of the country whose affairs he manages, and his next should be to take steps, with as little delay as possible, to make the same substance the nominal standard also, and to bring the subsidiary currency into conformity with it.

If we apply this test to the case of India, we are brought to the remarkable conclusion that never, in our time at any rate, was the standard of the country anything else but gold. This, indeed, is the opinion of Mr. Douglas, who approaches the question equipped with intimate practical knowledge of all its details. The parity maintained between silver and gold before 1873, by the fact that half the world was silver using, assisted by the French bimetallic law, effectually linked the retail money of India to the medium of its external trade. The rupee, under the old *regime*, was practically just as much a two-shilling piece as the florin is, and, unquestionably, it should have been kept at two shillings, as the Dutch guilder in Java was kept at its old parity. It is the perception of this truth that has made so many Anglo-Indians bimetallists. They have felt instinctively that the link ought

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* *cf.* Dr. Soetbeer's view: "Gold is directly or indirectly the sole measure of value in the wholesale trade of all commercial nations."

never to have been dissevered, and have grasped, consequently, at any project that professed to provide a means of renewing it. It is useless, however, to dwell on the past. The practical question of the moment is:—Can this link be renewed now; not, of course, at the old rate of two shillings, but at the present market value of the rupee, at or about 1s. 4d. The whole tenor of the above reasoning points to the conclusion that the proper course to be taken in order to renew the link would be, in the first place, to recognise the facts as they stand, to recognise that gold is already the standard of India, and to lose no time in making it the nominal standard as well. No better gold unit need be looked for than the English sovereign, and it should at once be made unlimited legal tender, and should have the mints opened to its free coinage. That being done, the next step that ought to be taken should be to make it the money of account in all Government business. All fixed payments in rupees due to the Government should then be converted into payments in pounds sterling, at the present market value of the rupee, or very close to it. The precise rate might be a matter for enquiry. To me it seems clear that the ideal rate of 15 rupees to the pound would be open to no objection. If, in these circumstances, a peasant's present rent was 15 rupees per annum, after its conversion he would, of course, continue to pay 15 rupees if he pleased, but his payment would then be called a payment of £1 sterling. It should next be notified that henceforward the rupee would be received in all payments that became due to the State at a fixed value of 1s. 4d. By adopting this course we should be creating a state of things in which a number of rupees, amounting to about four-fifths of the total circulation, would be annually, to all intents, redeemed in gold, at the par of 15 rupees to the sovereign, by the simple fact of their being received at that rate in the payment of taxes. There can be no doubt that that measure alone would effectually maintain the value of the rupee at the figure desired, without the accumulation of a shilling of gold reserve, or the adoption of any other precaution whatever. The fixing of the rate at which money shall be received in the payment of taxes has, throughout economic history, been found to be the most potent of all means which the State possesses for regulating its value. It was the announcement that the guinea would be so received in England that altered the whole situation there at the beginning of the eighteenth century. What was then intended was, of course, to fix the value of the guinea in the old standard—

silver. What was done was really to fix the value of the silver coins in the new standard—gold. Instead of the dog wagging the tail, it was the tail that, in the end, assumed the upper hand, and wagged the dog. No one dreamt then, of course, either of accumulating a silver reserve to redeem the gold, or a gold reserve to redeem the silver. When no liability is assumed, there can be no occasion for a reserve to cover a liability that does not exist. Turkey, a country from which we do not ordinarily think that we have much to learn, seems to have glided almost unconsciously into the use of the gold standard, like England in the eighteenth century, and to have maintained the silver medjidie at double its metallic value by simply closing her mints to silver, and allowing the gold coins of England and France to be used as unlimited legal tender. If it is objected, how would the system stand the strain of an unfavourable balance of trade? one may ask in reply, how would the present system stand it? India only meets her outside gold obligations now without a gold reserve, because she never has any actual gold, on balance, to send away, the balance of trade being uniformly in her favour. The new system would in that respect be, at any rate, as good as the old. In regard also to the protection of the note circulation, the rupees, maintained at 1s. 4d., would, at any rate, be as efficient as they are at present. To provide against a possible internal drain of gold, it would be desirable, in the meantime, no doubt, to imitate the practice of the Bank of the Netherlands, and to engage only to provide gold for export, and only in the event of the exchanges indicating that gold for export was needed. With that provision in force, experience points to the conclusion that, as in Java, practically none would be demanded. India, at any rate, it is plain, does not escape one shilling of her gold obligations because she has not formally adopted the gold standard, nor could its formal adoption make them, in the smallest degree, more onerous, or in any way more difficult to liquidate.

Professor Laughlin, in his "History of American Bimetallism," has occasion to remark that it had been a great puzzle to many people to understand how it was that the silver dollar, and the silver certificates based on it, which are not redeemable in gold, are, nevertheless, maintained at par with United States notes, which are. Among the reasons which he assigns as accounting for the fact, he lays the principal stress on this—that the statute ordains that these certificates "shall be receivable for customs, taxes, and

all public dues." This he regards as one of the most important provisions of the Act, and justly remarks that it is as a species of daily redemption of the silver dollar.

Though it was a far wiser course to close the mints, even without following up that step by any other legislation, than it would have been to let things run on in the old groove, still the decision to confine administrative action to that step alone was due, I think, in some degree to a false diagnosis of the disease to be cured. The Indian Government and the Herschell Committee seem to have come to the conclusion that the depreciation of the rupee bore a closer analogy to depreciations due to excessive issues of inconvertible paper than was, as a matter of fact, the case; and they consequently decided that the first, perhaps the only, necessity was to reduce the quantity of the currency. This, time and the closing of the mints, they satisfied themselves, would effect. The interesting fact, however, had been, even in 1892, established by Mr. F. C. Harrison, a member of the Indian Civil Service, in a series of papers contributed to the *Economic Journal*, that the Indian circulation had not expanded at all between 1873 and 1886, and that it had only very slightly expanded between 1886 and 1893. An immense quantity of silver was coined indeed, but more than three-fourths of it was immediately afterwards melted down and made into ornaments. This fact seems to point to the desirableness of a different sort of remedy from the mere reduction of the quantity of rupees in circulation. The cure may be possible by that method, but the method may not for all that be the right one—the one which would effect the cure most rapidly and most painlessly. The principle that underlies the policy of the closure of the mints may be stated thus:—There is some point in the progressive reduction of the circulation at which the rupee will reach the value of 1s. 4d., and the maintenance of the *status quo* will, in time, bring down the circulation to that point. What is forgotten, however, is this, that this point is not necessarily the same in one set of circumstances as it might be in another. If there is such want of confidence in the future stability of the value of the rupee that everyone is afraid to keep the coin in his possession more than a day, then the point where the redundancy ceases might be found, let us suppose, at a limit of 100 crores of a circulation; whereas, if people could feel confident that its value would be steadily maintained, then their own change of attitude towards it would very

largely assist to keep it out of circulation, and would thus fix the point where the redundancy would cease at a much higher figure, perhaps at 150 or 200 crores. If confidence in the coin were established, for example, agriculturists would not hesitate to lay rupees aside after harvest, and to keep them by them for the requirements of the winter, and that itself would be equivalent to an important reduction of the circulation, and one, too, which would take effect especially in the slack season, when it would be most opportune. If, then, a great market were created for the rupees at a fixed ratio to the pound, by their receipt in the payment of taxes, that itself would, beyond question, establish the required confidence, and would be sufficient to remove all danger of redundancy.

The suggestion, however, that the mints should be opened to the free coinage of gold, and that gold should be made unlimited legal tender in India, will be met, no doubt, by the objection that if that is done, then a further drain will be made on the gold resources of the world, and what is called its "appreciation" will be enhanced. To this a variety of replies suggest themselves. In the first place, one may ask, is there anything at all in this appreciation of gold theory? Does anyone seriously believe that gold is scarce, and is getting scarcer, in the face of the palpable fact that all the owners of it are competing with each other to lend as much of it as they can on anything like decent security, at 3 per cent. or under. In all the course of history it never was so plentiful. To my mind, instead of setting about to excogitate plans for keeping gold out of the Indian currency, while adopting it as the standard, we should rather be considering how most effectually to make it enter as largely as possible into that currency. The appreciated rupee may be made to work well enough in time of peace. It is, however, unquestionably a danger in time of war. If Russia were to invade India she would have occasion for the use of many millions of rupees, and it is not probable that she would buy them from us at 1s. 4d. when she could manufacture them for herself at a cost of 9d. Again, however, it must be asked, would the adoption of the system tend in any way whatever to increase the strain on the gold resources of the world, supposing that to be an evil? Once it was fairly established, on the contrary, it might be possible to draw no inconsiderable proportion of the £270,000,000 of gold that lies hoarded in India into the general circulation of the world by giving a

fractional advantage to payments of rents and taxes in gold as compared with similar payments when made in rupees. Falling silver money meant, of course, rising gold, and, so long as the fall in the rupee lasted, that fact formed a steady inducement to the hoarding of gold.

If, however, the bogey of gold scarcity still refuses to be laid, then it may be said that there does not appear to be any reason why the features of Mr. Probyn's or Mr. Lindsay's schemes, which would confine the actual use of gold to the wholesale trade, could not be adopted equally well after gold had been made the formal and nominal standard as they could before. The essential matter is that gold should be made the money of account for the country, the nominal as well as the real standard of all computations. Without that, the redemption of the rupee circulation, at a fixed rate in gold, by its receipt in the payment of taxes, would, of course, be impossible.

The closure of the mints and the experience that has been gained since have served, at any rate, to clear the course for future action. Time has disposed of one fancied difficulty that loomed very large in the eyes of economists five and twenty years ago, the supposition that any scheme involving the limitation of the rupee circulation would be upset by illicit coinage. People, too, quite recently, have come to know much better what it is that they want than they did even a short time ago. The discussions of the present year have tended in a marked manner to bring this about. There is no talk now of raising the rupee to two shillings again, as it was contended that the adoption of bimetallism at the old ratio would have done. That, it is seen, would be hardly a less evil than its fall by an equivalent amount. The sole aim of all practical men who have to deal with the subject now is to fix it permanently at 1s. 4d., and all that has in truth now to be considered is how best to effect that object.

One further point in connection with the standard of value seems worth touching on in conclusion. If it be true, as I have endeavoured to show, that the manner in which changes in a monetary system come about is—that, first, the money of wholesale and foreign trade changes its character, and, next, that legislation comes to be demanded, and should indeed forthwith be adopted, to make the internal money conform to it, then it is obvious that there must always be an underlying unity between the moneys of nations that have intimate and extensive trade relations with each

other, and that there must always be a tendency at work in the direction of making that unity more explicit and more complete. Sir Robert Giffen's doctrine, as laid down in the article in the *Nineteenth Century* already referred to, that before the closure of the mints India had one good automatic money, while England had another equally good, though wholly different from it, is a doctrine that bears its own refutation on its face. The bimetallists are perfectly right in their contention that the money of any one country can never be viewed as something apart from that of the rest of the world. The change from the silver to the gold standard in England appears to have originated in connection with her internal wholesale trade, before her foreign trade had yet become an important element in her economy; and its subsequent history gives us a striking view of the monetary predominance of Great Britain in the world. Mommsen speaks of the existence of a law in the development of nations as unfailing in its operation as the laws of physical nature itself, under which a community, with a strongly organised system of government, chancing to find itself situated in proximity to loosely organised nationalities, inevitably annexes and absorbs them. There appears to be a parallel law in operation in the monetary sphere. England, for over a century past, has possessed a highly organised system of credit and banking, while that of the rest of Europe remained till recently, comparatively speaking, in a primitive condition. London thus, as we know, became the clearing house of the world. The teas of China despatched to New York, and the cottons of America despatched to Calcutta, were alike paid for by sterling bills on London. Sterling thus became the medium practically of all the payments of the largest description everywhere, and the media of internal trade are now consequently everywhere being made to conform to sterling. This stormy, misty island of the Atlantic has given, or is giving, her language to a sixth of the human race; her constitution, in essentials, to a still larger proportion; and her standard of value to the whole of it.

VII.—*Lord Kelvin's Patents.* By Dr. MAGNUS MACLEAN.

[Read before the Society, 23rd February, 1898.]

§ 1. There are altogether 47 patents from 20th February, 1858, to 28th September, 1896, a period of 38 years. All of them can be conveniently classified under four heads:—

A. Patents relating to improvements in electric telegraphic apparatus.

B. Patents relating to improvements in navigational apparatus.

C. Patents relating to improvements in generating, regulating, measuring, recording, and integrating electric currents.

D. Patents relating to improvements in valves for fluids.

§ 2. Under the first head (A) there are 11 patents containing (1) 211 pages of descriptive reading, and (2) 24 large sheets having 127 separate figures or diagrams, as shown in the following tabular statement:—

Number of Patent.	Date of provisional Specification and of complete Specification.	Title of Patent.	Number of Pages.	Number of Sheets.	No. of Figs. or Diagrams.
329	Feb. 20, 1858 Aug. 19, 1858	Improvements in testing and working electric telegraphs.	36	1	9
329	May 19, 1871	Disclaimer.	19	—	—
2047	Aug. 25, 1860 Feb. 25, 1861	Improvements in the means of telegraphic communication.	37	4	27
1784	July 6, 1865 Jan. 6, 1866	Improvements in electric telegraphs.	14	1	9
2147	July 23, 1867 Jan. 23, 1868	Improvements in receiving or recording instruments for electric telegraphs.	10	1	7
3069	Nov. 23, 1870 Not allowed	Improvements in electric telegraph transmitting, receiving, and recording instruments, and in clocks.	33	—	—
252	Jan. 31, 1871 July 31, 1871	Improvements in transmitting, receiving, and recording instruments for electric telegraphs.	24	7	37
810	Mar. 25, 1871 Void.	Improvements in clocks and apparatus for giving uniform motion.	4	—	—
2086	June 12, 1873 Dec. 12, 1873	Improvements in telegraphic apparatus.	14	4	11
1095	Mar. 13, 1876 Sept. 13, 1876	Improvements in telegraphic apparatus.	16	4	21
24868	Dec. 28, 1895 Sept. 28, 1896	Improvements in recording instruments for telegraphic and other purposes.	4	2	6

Fleeming Jenkin was associated with Lord Kelvin in patents 2047 and 2086, and Cromwell Fleetwood Varley was associated with him in patent 1784.

§ 3. Under the second head (B) there are 10 patents containing (1) 89 pages of descriptive reading, and (2) 27 sheets having 151 separate figures or diagrams, as shown in the following tabular statement :—

Number of Patent.	Date of provisional Specification and of complete Specification.	Title of Patent.	Number of Pages.	Number of Sheets.	Number of Figures or Diagrams.
1339	Mar. 29, 1876 Sept. 27, 1876	Improvements in the mariner's compass and in the means of ascertaining and correcting its errors.	12	2	20
1339	Nov. 30, 1877	Disclaimer and memorandum of alteration.	8	—	—
3452	Sept. 1, 1876 Mar. 1, 1877	Improvements in apparatus for navigational deep-sea soundings.	8	1	9
4876	Dec. 18, 1876 June 15, 1877	Improvements in the mariner's compass and in appliances for ascertaining and correcting its errors.	17	3	22
679	Feb. 20, 1879 Aug. 20, 1879	Improvements in the mariner's compass and in appliances for correcting its errors.	8	2	15
781	Feb. 23, 1880 Aug. 23, 1880	Improvements in navigational sounding apparatus.	15	7	31
5675	Dec. 8, 1883 June 7, 1884	Improved navigational sounding apparatus.	7	3	12
5676	Dec. 8, 1883 June 7, 1884	Improvements in the mariner's compass and in the means for ascertaining and correcting its errors.	5	5	12
12240	Oct. 14, 1885 July 12, 1886	An improved navigational sounding machine.	6	2	24
8959	June 10, 1890 Mar. 10, 1891	Improvements in the mariner's compass.	3	2	6

§ 4. Under the third head (C) there are 24 patents containing (1) 177 pages of descriptive reading, and (2) 123 sheets having 287 figures or diagrams, as shown in the following tabular statement ;—

Number of Patent.	Date of provisional Specification and of complete Specification.	Title of Patent.	Number of Pages.	Number of Sheets.	No. of Figs. or Diagrams.
3032	July 9, 1881 Jan. 9, 1882	Improvements in regulating electric currents, and in the apparatus or means employed therein.	11	3	9
5668	Dec. 26, 1881 June 28, 1882	Improvements in dynamo-electric machinery, and apparatus connected therewith.	18	13	70 lapse
2028	April 21, 1883 Oct. 20, 1883	Improvements in apparatus and processes for generating, regulating, and measuring electric currents.	28	25	48
4617	Sept. 28, 1883 Mar. 27, 1884	Apparatus for generating, regulating, measuring, recording, and integrating electric currents.	41	18	36
4655	Mar. 10, 1884 Oct. 8, 1884	New or improved suspensions for electrical incandescent lamps.	4	1	2
5355	Mar. 22, 1884 Nov. 10, 1884	Improvements in dynamo-electric machinery.	3	1	5
6410	Mar. 10, 1884 Oct. 28, 1884	Improvements in breaking electric contact to prevent over-heating by imperfect contact.	3	2	6
10530	July 24, 1884 April 25, 1885	Safety fuses for electric circuits.	7	1	13
11106	Aug. 9, 1884 May 7, 1885	Improvements in apparatus for measuring electric currents.	10	6	7
9016	July 10, 1886 April 9, 1887	Improved apparatus for measuring the efficiency of an electric circuit. (Amended Oct. 4, 1897.)	13	28	40
18035	Dec. 11, 1888 Sept. 7, 1889	Electrostatic apparatus for measuring potentials.	4	3	7
18035*a*	Dec. 11, 1888 Sept. 7, 1889	An improved ampere-gauge and connections.	3	3	6
18035*b*	Dec. 11, 1888 Sept. 7, 1889	Improved apparatus for continuously measuring potentials or currents.	3	2	3
15769	Oct. 8, 1889 July 7, 1890	Apparatus for measuring and recording electric currents. (Allowed to lapse.)	4	3	4
1004	Jan. 20, 1891 Oct. 20, 1891	An improved indicator for electric potentials.	2	1	3
18436	Oct. 27, 1891 July 22, 1892	Improved apparatus for measuring and recording electric currents.	5	3	6
10230	May 30, 1892 July 2, 1892	An improved electric condenser.	2	2	2
2198	Feb. 1, 1893 Nov. 1, 1893	Improvements in balances.	2	1	5
2199	Feb. 1, 1893 Feb. 1, 1893	An instrument for measuring electric currents.	3	1	4
5733	Mar. 17, 1893 Dec. 16, 1893	Improved arrangement for reading the deflections of electric instruments.	2	1	2
24471	Dec. 20, 1893 Oct. 20, 1894	Improvements in electric supply meters.	3	1	2
24979	Dec. 29, 1893 Dec. 29, 1894	Improvements in instruments for measuring and recording electric pressures and currents.	1	3	5
15034	Aug. 7, 1894 —	Improvements in instruments for measuring electric currents.	—	—	—
2261	Nov. 27, 1895 Sept. 28, 1896	Improvements in apparatus for indicating and recording electric supply.	5	1	2

James T. Bottomley was associated with Lord Kelvin in patent 10530.

§ 5. Under the fourth head (D) there are two patents containing (1) 10 pages of descriptive reading, and (2) eight sheets having 25 separate figures or diagrams, as shown in the following tabular statement :—

Number of Patent.	Date of provisional Specification and of complete Specification.	Title of Patent.	Number of Pages.	Number of Sheets.	Number of Figures or Diagrams.
5471	Mar. 30, 1889 June 8, 1889	Improvements in valves for water, steam, or other liquids or gases.	4	3	8
3864	Mar. 4. 1891 Dec. 3, 1891	Improvements in valves for water, steam, or other liquids or gases.	6	5	17

There are, up to 28th September, 1896, 47 patents containing (1) 487 pages of descriptive reading, and (2) 182 sheets having 590* separate figures or diagrams.

§ 6. Under the first head reference was made to the "retardation" occasioned in electric impulses through long submarine cables by "electrostatic capacity," and the necessity of having a receiving instrument so sensitive as to be able to indicate or record continuously every variation in the strength of the received current. The mirror galvanometer and the siphon recorder†, which were briefly described, fulfilled these conditions.

§ 7. Under the second head, the sounding machine, the depth recorder, and the compass,‡ were exhibited and described. The three principal errors to be corrected in the compass—viz., the semicircular, the quadrantal, and the heeling errors were referred to, and the methods by which these are corrected in the Kelvin

* The number of separate diagrams is underestimated here, for in some cases the diagrams are numbered 1, 1A, 1B, 1C, etc., and these in the above counting are reckoned as one.

† For details see Kelvin's "Mathematical and Physical Papers," Vol. II.

‡ For details see Kelvin's "Popular Lectures."

compass were explained. Short reference was also made to the tide gauge, tidal harmonic analyser, and tide predicter.

§ 8. Under the third head reference was made (I.) to electrometers (§§ 10-28); (II.) to electromagnetic instruments for measuring currents and differences of potentials (§§ 29-45); (III.) to electrodynamic instruments for measuring currents and differences of potentials (§§ 46-59); and (IV.) to instruments arranged for recording and integrating electric currents (§§ 60-61)

I.—Electrometers were divided into two classes (*a*) symmetrical electrometers, and (*b*) attracted disc electrometers.

(*a*) 1. Quadrant electrometer.* By the heterostatic and idiostatic arrangements differences of potentials from $\frac{1}{100}$ volt to 100 volts can be accurately determined by this instrument.

2. Multicellular electrometers (40 to 1,600 volts) and dial electrostatic voltmeters reading to 2,400 volts.

3. Vertical electrostatic voltmeters (200 to 20,000 volts).

(*b*) 1. Absolute electrometer.

2. Long-range electrometer.

3. Portable electrometer.

4. Electrostatic balance (5,000 to 100,000 volts).

II.—1. Graded current galvanometers reading from $\frac{1}{250}$ ampere to 200 amperes.

2. Magnetostatic current-meters reading from $\frac{3}{10000}$ ampere to 300 amperes.

3. Ampere-gauges reading from $\frac{1}{4}$ ampere to 6,000 amperes.

4. Graded potential galvanometer reading from a small fraction of a volt to 200 volts.

III. Standard direct reading electric balances, reading from 1 centiampere to 10,000 amperes.

* For details see Kelvin's "Electrostatics and Magnetism."

IV.—1. Recording voltmeters and ampere-meters.

2. Electricity supply meter.

§ 9. Descriptions of some of the instruments under the third head appear in the *Proceedings* of the Society as follows :—

Vol. IV., 4th January, 1860.—Water dropper, divided-ring electrometer, and portable atmospheric electrometer.

Vol. XVIII., 20th April, 1887.—Vertical electrostatic voltmeter, marine ampere-meter, and marine voltmeter.

Vol. XIX., 4th February, 1888.—New composite electric balance.

Vol. XXIV., 30th November, 1892.—Ampere-gauge, electricity supply meter, and large dial voltmeter.

The following is a short description, collated and amended from different sources, of some of the most important electrical instruments, under the third head, invented and perfected since 1888 :—

C (I.).—ELECTROMETERS, §§ 10-28.

THE ELECTROSTATIC VOLTMETERS.

§ 10. These voltmeters have the great advantage of being available as accurate measures of potential on direct and alternating

FIG. 1.—Multicellular Electrostatic Voltmeter.

systems, and, being electrostatic, they use no current, and consequently require no temperature correction. They are, therefore, free from the causes of error so prevalent in instruments of the electro-magnetic type, whose accuracy is impaired by variations of temperature, and which, when used on alternating systems, are affected by errors due to self-induction varying with the period of alternation. The chain of electrostatic voltmeters measures from 40 to 100,000 volts, and is composed of three distinct types—viz., the multicellular electrostatic voltmeters, the vertical electrostatic voltmeters, and the electrostatic balance. Two types of the multicellular instrument are made—one with a horizontal scale for laboratory use, the other with a vertical scale and dead-beat action for engine-room use. The ranges of the separate instruments, as usually made, are:—

* Multicellular electrostatic voltmeter	range	40	to	160
	best of range	50	,,	100
* ,, ,, ,,	range	60	,,	240
	best of range	70	,,	130
* ,, ,, ,,	range	80	,,	400
	best of range	100	,,	240
* ,, ,, ,,	range	200	,,	800
	best of range	300	,,	600
* ,, ,, ,,	range	500	,,	1,600
	best of range	700	,,	1,300
Vertical ,, ,,	range	200	,,	4,000
,, ,, ,,	,,	400	,,	8,000
,, ,, ,,	,,	800	,,	12,000
,, ,, ,,	,,	1,000	,,	20,000
Electrostatic balance - - - - -	,,	5,000	,,	50,000
,, ,, - - - -	,,	10,000	,,	100,000

§ 11. The instruments are made on the principle of an air condenser, having one of its parts movable about an axis, so as to increase or diminish the capacity. The condenser is enclosed in a metal case, for the double purpose of protecting the movable part from air currents, and from the disturbing influence of any electrified body, other than the fixed portion, differing from it in potential. In all the instruments, except the electrostatic balance, the fixed portions consist of two sets of quadrant-shaped cells in metallic connection with each other, and formed by a number of parallel brass plates. These cells are fixed by an insulating support to the case of the instrument, and a terminal passes from them to an insulated binding screw on the outside of the case.

* The vertical scale multicellulars, as shown at Fig. 2, have shorter ranges than those given above. Their ranges correspond more closely to "best of range."

§ 12. The movable portion in all the instruments is in metallic connection with the surrounding case. In the multicellular voltmeters this connection is made through the suspending wire,

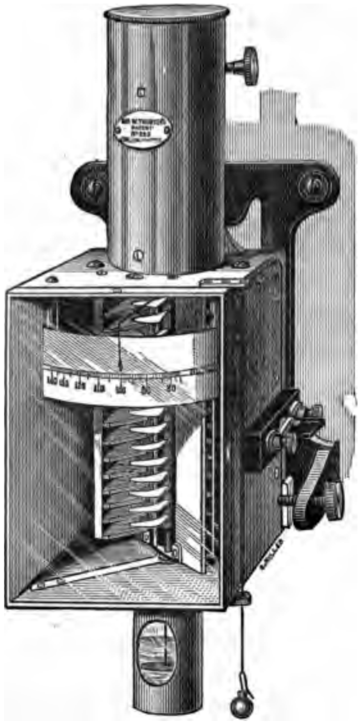

FIG. 2.—Vertical Scale Multicellular Electrostatic Voltmeter for Low-tension Circuits (Engine-room Pattern).

and in the vertical scale voltmeter and electrostatic balance through the knife-edges which support the movable part. The movable portion carries the pointer which indicates, by direct readings, the difference of potential between the two parts of the condenser.

§ 13. The action of the instrument, shortly stated, is as follows:—When the fixed and movable plates are connected respectively to two points of an electric circuit, between which there exists a difference of potential, the movable plate tends to move so as to augment the electrostatic capacity of the instrument, and the magnitude of the force concerned in any

case is proportional to the square of the difference of potential by which it is produced. In the use of the vertical electrostatic voltmeter and electrostatic balance this force of attraction is balanced by a weight of any convenient amount placed on the movable part; while in the case of the multicellular it is balanced by the torsion of the suspending wire.

THE MULTICELLULAR ELECTROSTATIC VOLTMETER.

§ 14. The arrangement of the parts of this instrument is shown in Fig. 3. This figure applies to an early form of the

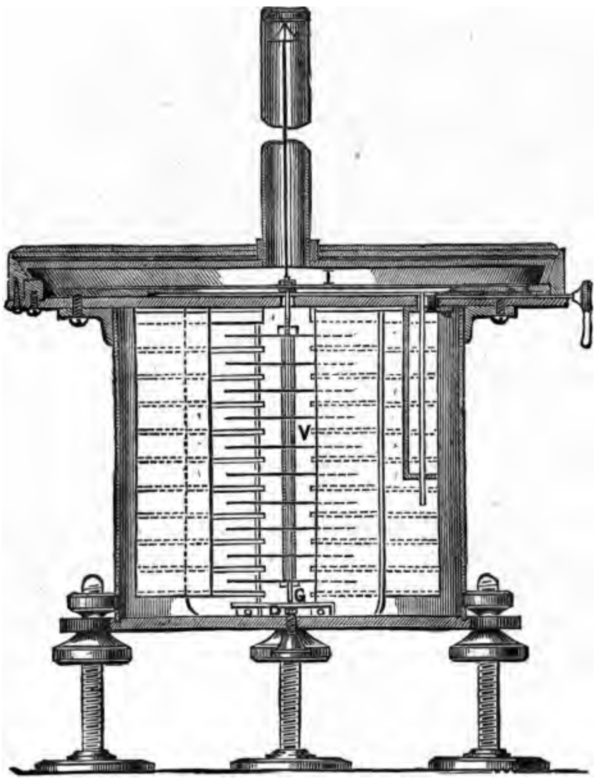

FIG. 3.

instrument, and differs in two matters of detail from the voltmeter as now made. For simplicity in manufacture the cells are now made with straight backs, and the plates looked at in plan

are, therefore, triangular instead of square. A coach spring has now been interposed between the suspending wire and the spindle carrying the vanes, as explained below.

§ 15. The insulated cells are formed of triangular brass plates fixed into saw cuts in a brass back-piece so as to be equal distances apart and accurately parallel to each other. Two sets of these cells are fixed by a vulcanite support to the sole-plate, so that their plates are horizontal, and are completely enclosed within the brass cylindrical case of the instrument. On the top of this cylinder is a shallow horizontal circular scale box containing the scale of the instrument, and having a glass cover, which serves to protect from currents of air the movable indicator, I, and the scale and interior parts from dust. For the movable part a number of vanes, V, similar in form to those of the quadrant electrometer, are used. These vanes are placed parallel to each other on a spindle with distance pieces between them. The top end of this spindle passes through a small hole in the sole-plate of the instrument, which forms the bottom of the scale box, and is attached to a small coach spring, which in turn is secured to one end of a fine iridio-platinum wire suspended from a torsion head at the top of a vertical brass tube. The torsion head may be turned by means of a forked key provided for the purpose, and is clamped, to protect it from accidental displacement, by a cap which screws on to the end of the tube. The coach spring has sufficient resilience to allow the spindle to touch a guard stop, and so saves the suspension from injury in event of the instrument being roughly set down.

§ 16. Two vertical brass repelling plates, which also act as guard plates to prevent the movable part from turning beyond its prescribed limits, are fixed to the bottom of the sole-plate. These two plates carry a guide plate, G, with a circular opening in it; through which the lower end of the spindle passes. A little brass disc, or head, D, is attached to the end of the spindle, sufficiently large to prevent its passing back through the hole in the guide plate. Thus the movable part is effectually secured from swinging about so as to be injured, and by no possibility can it come into contact with the insulated quadrants. When the instrument is level, the spindle hangs free by the suspending wire, so that the vanes are horizontal, and each is in a plane exactly midway between those of two contiguous condenser plates.

An aluminium needle attached to the top of the spindle indicates, on the horizontal circular scale fixed to the upper side of the sole-plate, the difference of potential between the movable and fixed portions of the condenser by direct readings in volts.

§ 17. *Engine-room Pattern Multicellular.*—The description of the instrument given above refers to the horizontal scale or laboratory pattern. In the new engine-room pattern the parts are in every way similar, but the instrument has a vertical scale. A vane attached to the spindle turns in an oil dash-pot, and gives the instrument a dead-beat action.

§ 18. *Portability.*—A small thumb-screw is placed in the centre of the base plate below the instrument, which can be screwed in so as to lift the weight of the spindle and vanes from the suspending wire and clamp the disc on the end of the spindle against the guide plate. A lifter or checker is also provided similar to that used in the magnetostatic instruments.

A switch is attached to the insulated terminal of the instrument by which the voltmeter can be taken out of circuit when desired. The switch, after breaking circuit, puts the case and the insulated cells in metallic connection.

Vertical Electrostatic Voltmeter.

§ 19. The instrument is shown in Fig. 4, and, as will be seen, the insulated quadrants are supported with their plates vertical, and only one large vane is used. This movable plate is supported in a vertical position on knife-edges, so that the plane of its motion is parallel to the two fixed plates which form the insulated quadrants. Its upper end has a fine prolongation which serves as a pointer for indicating the deflections on the scale of the instrument, and at its lower end is fixed the knife-edge for the weights, having its length perpendicular to the plane in which the plate moves.

In order to save time in taking readings, an arrangement is provided for checking the oscillations of the movable plate, and stops are placed to limit its range and prevent damage to the pointer. One of these stops, the left-hand one, is made to act as a support for the vane in the arrangement for portability.

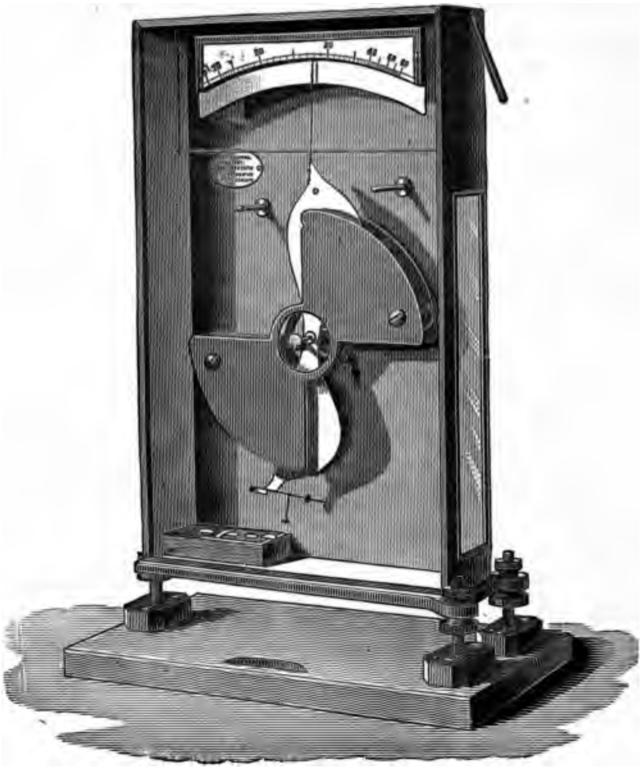

FIG. 4.

§ 20. The scale is graduated from 0 to 60, and the divisions represent equal differences of potential—the actual magnitude of the difference per division being dependent upon the weight in use at the time. A set of three weights is sent with each instrument, providing for three grades of measurement in the proportion of 1 : 2 : 4. Thus the instrument shows one division per 50 volts with the link (the lightest weight) alone, one division per 100 volts with the medium weight hanging on the link, and one division per 200 volts with all three weights on.

THE ELECTROSTATIC BALANCE.

§ 21. The arrangement of the parts of this instrument is shown in Fig. 5. The fixed portion of the condenser in this instrument

is a brass disc, B, which is supported from a slate base, S, on three glass pillars, P. The disc is provided with the well-known Thomson "hole, slot, and plane" arrangement, so that it always rests in exactly the same position on its supports.

A wire thickly covered with india-rubber passes from a terminal, T, through a glass tube, C C C, and makes connection with the disc by a spring contact, the glass tube being filled with paraffin to prevent the lodgment of moisture and give great resistance to disruptive discharge. A sheath formed by a short

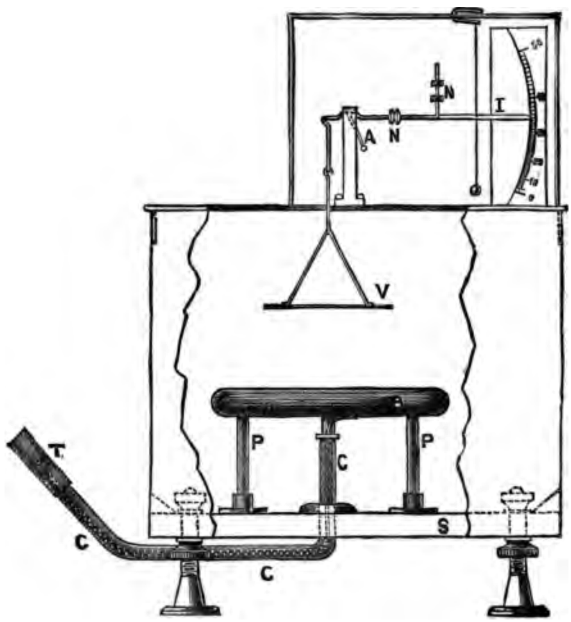

FIG. 5.

piece of glass tube pulls up over the terminal, T, and protects it from being touched by accident. The base plate is provided with three screw levelling feet. A brass case fits upon the base plate, and fixed to its top is a metal scale box with a glass front which contains the indicator and scale. The movable part, V, is a round aluminium plate, supported by two long links, which pass through a slit in the top plate of the case to two knife-edge stirrups on one end of the counterpoised indicator, I. The whole movable portion is supported by knife-edges on two brass pillars

and has a short arm, A, with a knife-edge stirrup at its extremity attached to its axis. The weights which fix the constant of the instrument hang on this stirrup.

§ 22. The instrument has a scale with divisions corresponding to equal differences of potential. The scale is graduated from 0 to 50, and three weights are provided such that, with the first hung on, the constant is 250 volts per division; with the second weight on, it is 500 volts per division; and with the third weight on, 1,000 volts per division.

Improved Gold-Leaf Electroscope for the Approximate Measurement of Potentials above 500 Volts.

§ 23. The instrument is an improvement upon the well-known electroscope, in which a pair of gold leaves, pith balls, or other light bodies are used for showing by their mutual repulsion some of the elementary phenomena of electrification. The object of the invention is to provide a convenient means of measuring approximately differences of potentials in cases where the accuracy of an electrometer is not required, and where its consequent expense would be a serious consideration. In the instrument to be described only one narrow gold leaf is used, and this is attached by a clamp to a broad plate of brass as shown in Fig. 6. This brass plate is

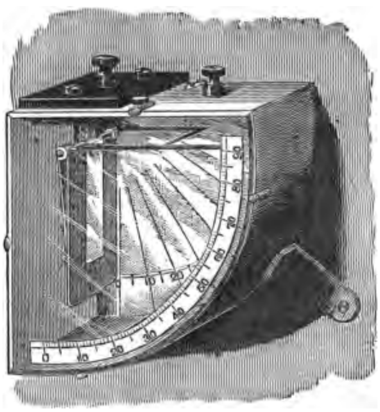

Fig. 6.—Gold-Leaf Electroscope.

supported on a block of vulcanite from the roof to the case, and has a binding screw attached to it. The case of the instrument—

with the exception of the front, which is of glass—is of metal, and the portion below the leaf is cylindrical in shape so as to obtain from its inductive action a wide range of sensibility. A scale is engraved upon the back of the case, and another is placed in front close to the glass in order that the deflections of the instrument may be read off without error due to parallax. A hinged frame is attached to the repelling plate, which folds down over the leaf to prevent damage during carriage, and when turned up as shown in the figure it acts by repulsion as a guard which effectually prevents the leaf from touching the roof of the case at abnormally high potentials. Two terminals are provided; one is attached to the case, and the other on the vulcanite block is in metallic connection with the repelling plate and the gold leaf. The instrument, as above stated, is intended mainly as an approximate potential indicator for high-potential circuits, and it may be used with advantage as a constant indicator to test the equality of the pressures between earth and each of the two primaries of a high-tension system. It is also useful to test that the potential of the secondary or distributing circuit is less than 200 volts. As a lecture-room instrument it will be found more convenient and less liable to damage than the ordinary forms of electroscopes hitherto employed.

Standard Air Leyden Condenser for the Determination of Small Electrostatic Capacities.

§ 24. The apparatus to be described affords, in conjunction with a suitable electrometer, a convenient means of quickly measuring small electrostatic capacities, such as those of short lengths of cable. The instrument is formed by two mutually insulated metallic pieces, which we shall call A and B, constituting the two systems of an air condenser, or, as we shall now call it, an air leyden. The systems are composed of parallel plates, each set bound together by four long metal bolts. The two extreme plates of set A are circles of much thicker metal than the rest, which are all squares of thin sheet brass. The set B are all squares, the bottom one of which is of much thicker metal than the others, and the plates of this system are one less in number than the plates of system A. The four bolts binding together the plates of each system pass through well-fitted holes in the corners of the squares; and the distance from plate to plate of the same set is

regulated by annular distance pieces which are carefully made to fit the bolt, and are made exactly the same in all respects. Each system is bound firmly together by screwing home nuts on the ends of the bolts, and thus the parallelism and rigidity of the entire set is secured.

§ 25. The two systems are made up together, so that every plate of B is between two plates of A, and every plate of A, except the two end ones, which only present one face to those of the opposite set, is between two plates of B. When the instrument is set up for use, the system B rests, by means of the well-known "hole, slot, and plane" arrangement,* engraved on the under side of its bottom plate, on three glass columns which are attached to three metal screws working through the sole-plate of system A. These screws can be raised or lowered at pleasure, and, by means of a gauge, the plates of system B can be adjusted to exactly midway between, and parallel to, the plates of system

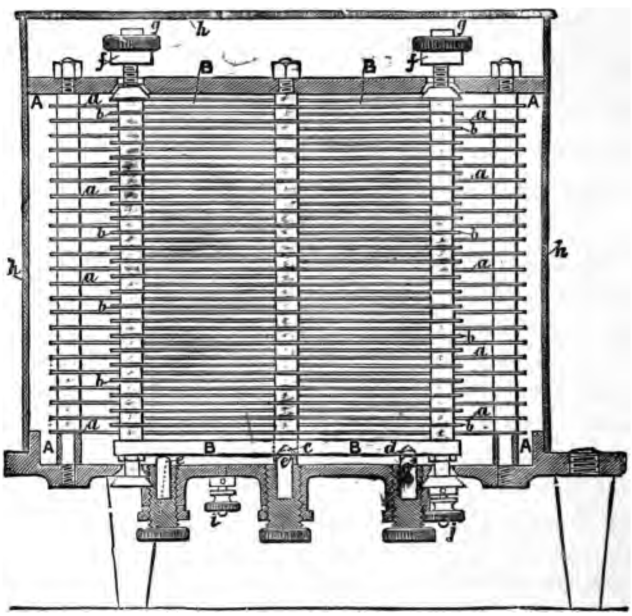

FIG. 7.

* Thomson and Tait's "Natural Philosophy," § 198, Example 3.

A. The complete leyden stands upon three vulcanite feet attached to the lower side of the sole-plate of system A.

§ 26. In order that the instrument may not be injured in carriage, an arrangement, described as follows, is provided by which system B can be lifted from off the three glass columns and firmly clamped to the top and bottom plates of system A:—The bolts fixing the corners of the plates of system B are made long enough to pass through wide conical holes cut in the top and bottom plates of system A, and the nuts at the top end of the bolts are also conical in form, while conical nuts are also fixed to their lower ends below the base-plate of system A. Thumbscrew nuts, *f*, are placed upon the upper ends of the bolts after they pass through the holes in the top plate of system A. When the instrument is set up ready for use these thumbscrews are turned up against fixed stops, *g*, so as to be well clear of the top plate of system A; but when the instrument is packed for carriage they are screwed down against the plate until the conical nuts mentioned above are drawn up into the conical holes in the top and bottom plates of system A; system B is thus raised off the glass pillars, and the two systems are securely locked together so as to prevent damage to the instrument. A dust-tight cylindrical metal case, *h*, which can be easily taken off for inspection, covers the two systems and fits on to a flange on system A. The whole instrument rests on three vulcanite legs attached to the base-plate on system A, and two terminals are provided—one, *i*, on the base of system A, and the other, *j*, on the end of one of the corner bolts of system B.

§ 27. The air leyden which has been thus described is used as a standard of electrostatic capacity. To explain its use in connection with an idiostatic electrometer for the direct measurement of the capacity of any insulated conductor, suppose, for example, this insulated conductor to be the insulated wire of a short length of submarine cable core, or of telephone, or telegraph, or electric light cable, sunk under water, except a projected portion, to allow external connection to be made with the insulated wire. The electrometer which is found most convenient is the "multicellular voltmeter," rendered practically dead-beat by a vane under oil hung on the lower end of the long stem carrying the electric "needles" (or movable plates).

To give a convenient primary electrification for the measurement,

a voltaic battery, V V′, of about 150 or 200 elements, of each of which the liquid is a drop of water held up by capillary attraction between a zinc and copper plate about 1mm. asunder. An ordinary electric machine, or even a stick of rubbed sealing-wax, may, however, be used, but not with the same facility for giving the amount of electrification desired as the voltaic battery. One end of the voltaic battery is kept joined metallically to a wire, W, dipping in the water in which the cable is submerged, and with the case, C, of the multicellular, and with the case and plates, A, of the leyden, and with a fixed stud, S, forming part of the operating key to be described later. The other end of the voltaic

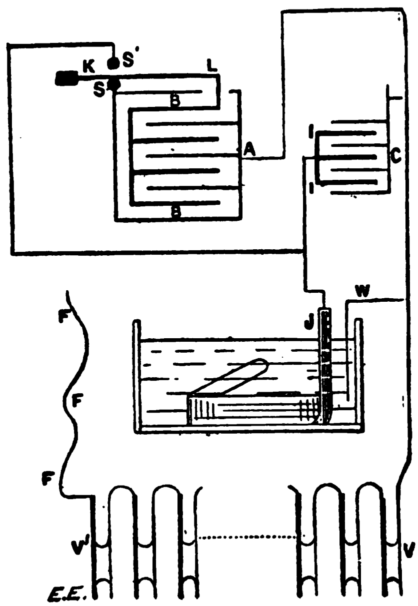

FIG. 8.

battery is connected to a flexible insulated wire, F F F, used for giving the primary electrification to the insulated wire, J, of the cable, and the insulated cells, I I, of the multicellular kept metallically connected with J. The insulated plates, B, of the leyden are connected to a spring, K L, of the operating key referred to above, which, when left to itself, presses down on the metal stud, S, and which is very perfectly insulated when lifted from contact with S by a finger applied to the insulating handle, K. A second well-insulated stud, S′, is kept in metallic connection with J and

I (the insulated wire of the cable and the insulated cells of the multicellular).

§ 28. To make a measurement, the flexible wire, F, is brought by hand to touch momentarily on a wire connected with the stud, S′, and immediately after that a reading of the electrometer is taken and watched for a minute or two to test either that there is no sensible loss by imperfect insulation of the cable and the insulated cells of the multicellular, or that the loss is not sufficiently rapid to vitiate the measurement. When the operator is satisfied with this he records his reading of the electrometer, presses up the handle, K, of the key, and so disconnects the plates, B, of the leyden from S and A, and connects them with S′, J, I. Fifteen or twenty seconds of time suffice to take the thus diminished reading of the multicellular, and the measurement is complete. The capacity of the cable is then found by the analogy: as the excess of the first reading of the electrometer above the second is to the second, so is the capacity of the leyden to the capacity of the cable. A small correction is readily made with sufficient accuracy for the varying capacity of the electrometer according to the different positions of the movable plates, corresponding to the different readings, by aid of a table of corrections determined by special measurements for capacity for the purpose on the multicellular.

C (II.).—ELECTROMAGNETIC INSTRUMENTS, §§ 29-45.

POTENTIAL GALVANOMETER.

§ 29. This instrument consists essentially of a coil of insulated copper or German-silver wire, the resistance of which is generally over 5,000 ohms, fixed to one end of a platform, on which a magnetometer rests. The magnetometer is supported on three feet and a spring; two of these feet slide in a V groove, cut in a slip of hardwood let into the top of a platform, and this allows the magnetometer to be moved nearer to or farther from the coil, but prevents it being so turned round as to change the zero reading of the instrument.

§ 30. To set up the instrument for use, place it with the plane of the coil in the magnetic meridian by turning the instrument until the index of the magnetometer points to zero on the scale when the semi-circular magnet is removed, and level it by turning the screws shown at the front of the platform until the bubble of the circular level attached to the magnetometer stands in the

centre of the level. The sensibility of the instrument is changed by changing the position of the magnetometer on the platform. When the front of the magnetometer is placed at any division of the scale marked on the platform, the number stamped at that division indicates the deflection, in divisions of the magnetometer scale, produced by one volt difference of potential between the ends of the coil, the intensity of the magnetic field in which the magnetometer needles are placed being supposed unity. In order to avoid as much as possible errors due to changes in the magnetic field produced by local influences, a permanent magnet of semicircular shape is supplied with each instrument for the purpose of producing a field at the magnetometer needle much more intense than that of the earth. This magnet is placed on the magnetometer in the position shown in Fig. 9, and its field brought into parallelism with that of the earth by turning the screw at the point of the magnet until the magnetometer index points to zero. The absolute intensity of the magnetic field at the needle due to this magnet alone is carefully determined and, with the date of the determination, marked on the magnet before the instrument is sent out. The total intensity of field is obtained by adding the horizontal component of the intensity of the earth's field to the number marked on the magnet. To avoid accidental demagnetisation of the magnet, it must be kept at a distance from all other magnets. A fall or violent shock of any kind may also alter the magnetisation of the magnet, and must, therefore, be avoided. It is desirable that the field which the magnet gives at the needles should be determined from time to time. This may be done for the potential instrument by means of a standard cell, and for the current instrument by electrolysis.

§ 31. In order to facilitate the use of the instrument, a pair of flexible electrodes, about 4 yards long, are supplied with it. These electrodes are shown attached to the instrument in the figure. The spring clips attached to the ends of the electrodes allow the instrument to be readily put in contact with two points of a circuit. To prevent a current passing through the coil when no reading is being taken, a key is placed in the circuit of the coil. This key should on no account be permanently short-circuited, because the coil becomes heated when a continuous current is allowed to flow through it, and is consequently increased in resistance. The indications of the instrument are thus made too small.

§ 32. To determine the difference of potentials between two points of a circuit, an electrode is clipped on at each of the points and then the key is depressed and the deflection noted. If the deflection is too great the magnetometer must be pushed to a division further from the coil, if too small to a division nearer the coil. The number of divisions in the deflection is then to be multiplied by the number on the magnet, plus the proper number —say, for example, ·16—for the earth's force, and divided by the number at the division of the scale on the platform exactly under the front of the magnetometer. The result is the required difference of potential in volts. That is to say, the coefficient for volts corresponding to any division on the platform scale is obtained by dividing the intensity of the magnetic field by the number at that division. When the difference of potential to be measured exceeds 200 volts, the readings of deflection must be taken as quickly as possible on account of the rapid heating of the coil. The rise of temperature for any short time, T, may be taken as $v=\frac{E^2 T}{R J K}$, where E is the difference of potential and R the resistance in absolute measure, T the time in seconds, J Joule's mechanical equivalent of heat, and K the thermal capacity of the coil.

For example, let $E=200$ volts;

$$R=5{,}000 \text{ ohms};$$
$$T=30 \text{ seconds};$$
$$J=4{\cdot}2\times10^7;$$
$$K=400.$$

$$\text{Thus } v=\frac{200^2\times10^{16}\times30}{5\times10^{12}\times4{\cdot}2\times10^7\times400}=0{\cdot}17\,\text{C. rise of temperature.}$$

The temperature of the coil at which the numbers on the platform scale are correct is stamped on the instrument. The following table gives the coefficients by which the deflections must be multiplied when the temperature of the coil differs by any number of degrees less than 20 from the temperature at which the instrument is correct. The first column gives the difference between the actual temperature and that at which the instrument is correct, in degrees centigrade; the second column gives the corresponding coefficient for copper coils when the difference is positive; the third column gives the coefficient when the difference is negative; the fourth and fifth columns give the corresponding coefficients for German-silver coils :—

1°	1·004	·996		
2	1·008	·992		
3	1·012	·988		
4	1·016	·984		
5	1·020	·980	1·002	·998
6	1·023	·977		
7	1·027	·973		
8	1·031	·969		
9	1·035	·965		
10	1·039	·961	1·004	·996
11	1·043	·957		
12	1·047	·953		
13	1·051	·949		
14	1·055	·945		
15	1·059	·941	1·007	·993
16	1·062	·938		
17	1·066	·934		
18	1·070	·930		
19	1·074	·926		
20	1·078	·922	1·009	·991

§ 33. *Current Galvanometer.*—This instrument is similar in form to the potential galvanometer with the exception that the coil is made up of a few turns of thick copper strip, and has a resistance of only about $\frac{1}{1000}$ of an ohm. Any current the intensity of which is less than 100 amperes may be safely measured by this instrument. The number at any division of the scale on the platform indicates the deflection which an ampere of current produces when the magnetometer is set with its front edge at that division and the intensity of the magnetic field is unity. The mode of setting up this instrument for use is precisely the same as that described above for the potential galvanometer.

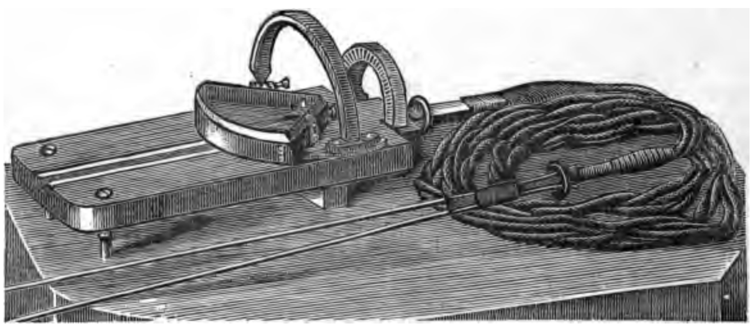

FIG. 9.—Graded Current Galvanometer.

To find the number of amperes corresponding to a deflection—*Rule*: Multiply the number of divisions in the deflection by the

number on the magnet plus the horizontal intensity of the earth's field, and divide by the number at the division on the platform scale exactly under the front of the magnetometer.

§ 34. Terminal pieces of the form shown in the figure are attached to the coil, and to the electrodes supplied with the instrument. When the electrodes are being removed from the coil or from the leads, the two sides of the spring terminal piece should come into contact with each other before they are out of contact with the plates of the other terminal pieces. When this is attended to the circuit is not interrupted, and hence sparks are avoided. A separate terminal piece, shown in the figure with two short wires attached, is also supplied, for the purpose of allowing the galvanometer to be easily introduced or removed from the circuit. This terminal piece is made to form part of the circuit the current through which is to be measured. By adopting this arrangement the galvanometer can be readily removed from one circuit to another.

ADJUSTABLE MAGNETO-STATIC CURRENT METER.

§ 35. The magneto-static current meter (Fig. 10) consists essentially of a small steel magnet or system of magnets suspended

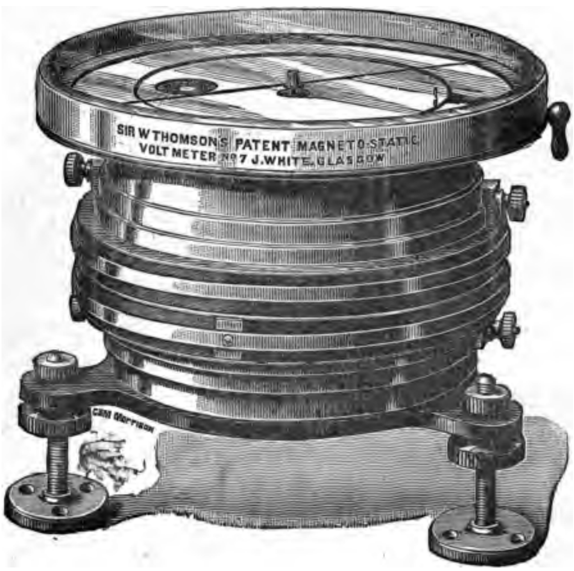

FIG. 10.—The Magneto-static Current Meter.

in the centre of a uniform field of force due to two coils, each having one or more turns of copper ribbon or wire, and also under the directive influence of two systems of powerful steel magnets. The suspended system of magnets is attached to one end of a vertical shaft passing down centrally through an opening in the sole-plate of the instrument from an indicating needle, which is supported by a jewelled cap resting upon an iridium point. The two systems of directive magnets are circular in form, and each ring is composed of two semi-circular magnets placed in a brass cylindrical frame with their similar poles together. Each system is securely fixed to a circular brass frame, which fits on to the cylindrical case of the instrument in such a manner that the systems are capable of being turned round, together or separately, as explained below.

§ 36. The instrument has a "tangent scale," which is adjusted in its position before the instrument is sent out, so that the needle indicates equal differences of readings for equal differences of current. The scale consists of a hundred divisions, and for most purposes it is convenient to set the field magnets in such a position that the needle points to 0, and to use the scale from that point upwards towards 100. Sometimes, however, it may be found convenient to measure currents, whose direction is being occasionally reversed, without being at the trouble of reversing the electrodes in the contact clip; in that case the zero should be set to the division 50 at the middle of the scale, and readings taken on each side of it. It must be remembered that when the point taken as zero is changed, the constant, by which the indications of the instrument have to be multiplied to give the current in amperes, is changed in proportion to the cosine of the angle between the zero point and the middle of the scale; and as this angle is 60 degrees, the constant with the zero at 50 on the scale is exactly double the constant with the zero at 0 on the scale. The instrument is provided with a "lifter," which serves to raise the needle off the iridium point when it is being moved about from place to place. This lifter is in the form of a ring placed below the needle, and may be raised or lowered by turning the handle attached to an eccentric passing through the side of the instrument on a level with the scale. It also serves as a checker, by bringing it lightly into contact with the pointer, so as to stop its vibrations.

§ 37. The two grades of this instrument which are found most convenient are—the milliampere-meter, which has an effective range of from ·3 to 300 milliamperes, and is usually adjusted to read two milliamperes per division, and the ampere-meter, which has an effective range of from ·3 to 300 amperes, and is usually adjusted to read one ampere per division; in both grades with the zero at 0 on the scale. If desired, instruments can be supplied having the constants adjusted to any value. The very wide range of accurate measurement given by these instruments makes them invaluable for laboratory use.

§ 38. The instrument has an advantage, important for some practical purposes, of being available as an accurate direct-reading current meter, through a continuous range of from 1 to 100 times its smallest current, which may be anything from half a milliampere to four amperes, according to the number of turns in the coils supplied with the instrument. It is not, however, available as an alternate-current instrument, and it must be remembered that the magnetism of the steel directing magnet does not remain absolutely constant. With good quality of steel, a proper preliminary ageing of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage) brings it to a condition in which its magnetism is found to remain exceedingly nearly constant month after month and year after year. Still, it should never be relied upon as absolutely constant, and for accurate laboratory work it is therefore necessary to have some means of retesting the instrument at any time. This is always easily done with the utmost accuracy if one of the balance instruments, to be described below, is available as a standard. Another advantage which the instrument has is that, when a standard instrument is available, its constant is capable of being varied to any desired value down to one-tenth of that which it has with its directive magnets in their strongest position. Thus, if the constant should be three amperes per division of the scale, with the similar poles of the magnets coinciding, it may be adjusted to any value down to 0·3 ampere per division. Instruments of this class are made to suit all ranges from 0·0001 to 3 amperes per division.

§ 39. One very convenient use of the instrument is to act as a lamp counter for indicating the number of incandescent lamps in use in an installation. For this purpose it is best to standardise

it by putting on a known number of lamps and adjusting as described below until the desired reading is obtained on the scale. Of course, this numbering of lamps is not possible to any great accuracy, because the lamps themselves are not all rigorously equal in the amount of current which each takes, but the lamp counter serves the important practical purpose of showing at any time the number of lamps in use nearly enough for practical purposes. In private houses this is very useful as a check against some lamp or lamps being left accidentally alight in a cellar, or safe-room, or box-room, or other place where the fact of its being alight might escape observation for days or weeks together. To count larger numbers of incandescent lamps, up to 1,000 or more, the instrument is made with smaller rings of more massive conductor, and the same proportionate accuracy is attained as with the 100-lamp counter.

§ 40. The milliampere-meter, on account of the low resistance of its copper coil—about 40 ohms—may conveniently be used as a voltmeter. To adapt it for this purpose, a copper cylinder, wound anti-inductively with two platinoid resistances, is supplied. The first of these, together with the resistance of the instrument, makes up 100 ohms, and the second alone is 900 ohms. Thus, taking the constant of the instrument at two milliamperes per division, by joining the smaller in series with the instrument, the reading on the scale will be one-fifth of a volt per division; with both resistances in series with the instrument, the reading will be two volts per division.

Portable or Marine Voltmeters and Amperemeters.

§ 41. For the measurement of potential in connection with electric lighting or power installations on board ship, the mass of the moving part of the balance voltmeter and engine-room voltmeter is too great to be convenient for accurate use. The marine voltmeter now to be described is specially suitable for such a purpose, but it is also equally useful as a portable voltmeter for general use. The resistances to enable the instrument to be used as a voltmeter are wound anti-inductively on two brass cylinders, and the lower one of these may be arranged to serve as a convenient means of supporting the instrument on a table or shelf. When, as is most commonly the case, the mean potential to be measured is 100 volts, the platinoid resistance is adjusted to make up, along with the fine copper wire solenoid (of which the resis-

tance is about 60 ohms), a total resistance of 1,000 ohms. Thus, the direct reading of potential on the scale is in volts.

In order to save time in taking readings, a checker is provided. A brass arc, capable of moving in a vertical direction, is placed parallel to and slightly below the plane in which the pointer moves, and by means of a handle this arc may be brought gently and momentarily into contact with the pointer so as to quickly stop its oscillations. When the instrument is to be used for very accurate work, a means of observing and annulling any error due to residual magnetism in the oblate may be provided by a reversing key placed below the scale box, and two magnets screwing into the sheath. The current through the instrument is made in one direction when the handle of the reversing key is in the top position, and made in the opposite direction when the handle is in the bottom position. The current is broken when the handle is on either side. The residual effect in the instrument is very small, and it is found to be sufficiently accurate for all practical purposes without this adjustment.

§ 42. *The Marine Ampere-meter.*—The marine ampere-meter is similar to the marine voltmeter as described above, with the

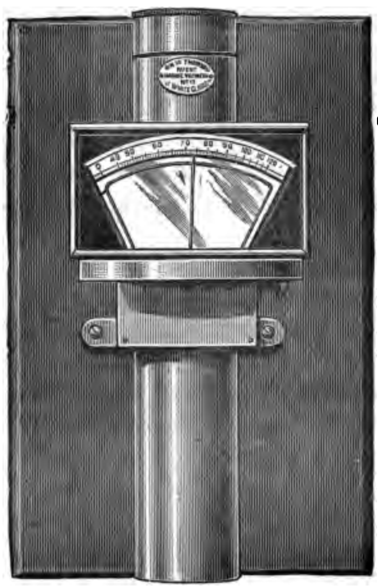

Fig. 11.—Portable or Marine Voltmeter.

exception that its solenoid is made from one or more turns of heavy copper conductor. Three ranges of the instrument are usually made—viz. (I.) 40 to 160; (II.) 60 to 270; (III.) 100 to 500.

The instrument consists of a small oblate of soft iron supported on a stretched wire in the centre of a solenoid of fine copper wire connected in series with platinoid resistances, variable according to the potential to be measured, and is founded on the principle that an oblate spheroid of soft iron, movable round a diameter, tends to turn its equatorial plane parallel to the lines of force in a uniform magnetic field. The pointer is fixed relatively to the oblate in such a manner that, when the pointer is at the zero position of the scale, the equatorial plane of the oblate is inclined about 45 degrees to the lines of force of the solenoid. The suspending wire is stretched between the two ends of a brass tube, being fixed at the bottom end and carried at the upper end by a torsion head, which is secured by screwing down upon it the movable cap of the top resistance coil. Portions of the tube are cut away to permit of easy access to all parts of the instrument for adjustment or inspection. In order to prevent damage to the suspending wire or accidental disturbance of the torsion head, two brass cylinders, which also serve to carry the resistance coils, are placed covering the two ends of the supporting tube, and are fixed by screws to the sheath. The scale is graduated from zero to 140, but for convenienee of observation the first marked division is 50. It is placed in a horizontal box with a glass cover fixed to the sheath, and the pointer shows by inspection direct reading of currents of from 50 to 140 milliamperes. The instrument is provided with a mirror so that its scale can be read from a distance.

The Ampère Gauges.

§ 43. These instruments are intended for use on switchboards where, on account of the intense field of their solenoids, and the fact that their movable magnetic system is always vertical, they are found to be free from effects of board currents. The ranges of the different types of the instrument usually made are :—

I.	From	·25	to	5	amperes.
II.	,,	1	,,	20	,,
III.	,,	5	,,	100	,,
IV.	,,	10	,,	200	,,
V.	,,	25	,,	500	,,
VI.	,,	50	,,	1,000	,,
VII.	,,	200	,,	2,000	,,
VIII.	,,	600	,,	6,000	,,

The instrument is of simple construction, having a vertical slate base-plate, to which are attached (*a*) a solenoid of special form, having a very intense field; (*b*) brass bearing plates supporting a balance which carries a soft-iron plunger on its one arm and a brass counterpoise weight on the other; (*c*) a brass arc having a scale graduated to give direct readings in amperes.

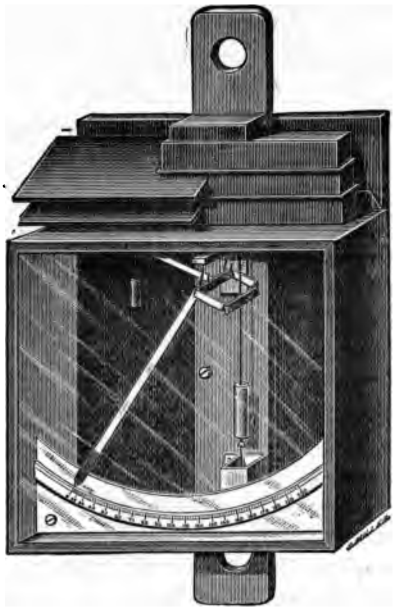

FIG. 12.—Ampere Gauge.

§ 44. The solenoid is built up of copper plates with mica insulation between them, and is fixed to the base-plate so that its core is vertical. The balance is supported on knife-edges at such a distance below the solenoid that the top end of the plunger is slightly entered into the core. The plunger is made from a thin soft-iron wire about 20 cm. long, and is supported by a cross-bar with two hooks on it, which pass over two knife-edge stirrups on the arm of the balance. It has a brass weight hung on its lower end in order to keep it in a vertical position and prevent its being attracted against the side of the solenoid. An indicating needle, or pointer, formed from a strip of platinoid, passes down from the trunnion of the balance to the brass arc bearing the graduated scale. As the plunger is attracted upwards, this

pointer passes round the scale and indicates the strength of current passing through the solenoid. A dash-pot containing oil is placed below the plunger and renders the instrument "dead-beat" in its action. When the instrument is packed for carriage, the plunger and pointer are removed and packed in a separate cardboard box. They should not be put into place in the instrument till it is fitted in its working position. The instrument should be secured to a wall by means of its electrodes, so that the pointer is in the same plane with the scale and stands at 0 when no current is passing through the solenoid.

TESTING SET FOR MEASUREMENT OF INSULATION RESISTANCE.

§ 45. The testing set (Fig. 13) consists of (1) a very sensitive galvanometer, whose deflections are directly proportional to the amount of current passing through its coil; (2) a magnet for con-

FIG. 13.

trolling the sensibility of the galvanometer; (3) a set of shunts which reduce the indications of the galvanometer to $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{500}$; (4) a set of compensating resistances controlled by shunt switch,

keeping the resistance of the galvanometer circuit constant whether shunted or not; (5) a switch enabling deflection to be taken through the galvanometer alone for standardising, or through the galvanometer and unknown resistance when making test. The main advantages of the instrument are:—(1) Great sensibility; (2) long range of measurement; (3) it is simple to use, and with it rapid tests can be made; (4) can be used with a separate battery or with potential of lighting circuit whose insulation is under test; (5) no plugs to get lost; (6) all connections marked on vulcanite base; (7) great portability.

C (III.).—ELECTRODYNAMIC INSTRUMENTS, §§ 46-59.

STANDARD DIRECT-READING ELECTRIC BALANCES.

§ 46. These instruments are founded on the mutual forces, discovered by Ampére, between movable and fixed portions of an electric circuit. The shape chosen for the mutually-influencing portions is circular, and each such part will be called for brevity an ampere ring; or sometimes simply a ring, whether it consists of only one turn or of any number of turns of the conductor; or an arc when it consists of less than a whole turn. In each of the balance instruments, except the kilo-ampere balance, each movable ring is actuated by two fixed rings—all three approximately horizontal. There are two such groups of three rings—two movable rings attached to the two ends of a horizontal balance arm pulled, one of them up and the other down, by a pair of fixed rings in its neighbourhood. The current is in opposite directions through the two movable rings to practically annul disturbance due to horizontal components of terrestrial or local magnetic forces. In a kilo-ampere balance the whole current passes through a single fixed ring and divides through two halves of a movable ring, which are urged one up and the other down by the resulting amperian force. In all the instruments the balance arm is supported by two trunnions, each hung by an elastic ligament of fine wire, through which the current passes into and out of the circuit of the movable rings or ring.

§ 47. In all the balance instruments in which the movable ring is between two fixed rings, the mid-range position of each movable ring is in the horizontal plane nearly midway between the two fixed rings which act on it. The current goes in opposite directions through the two fixed rings, so that the movable ring is attracted

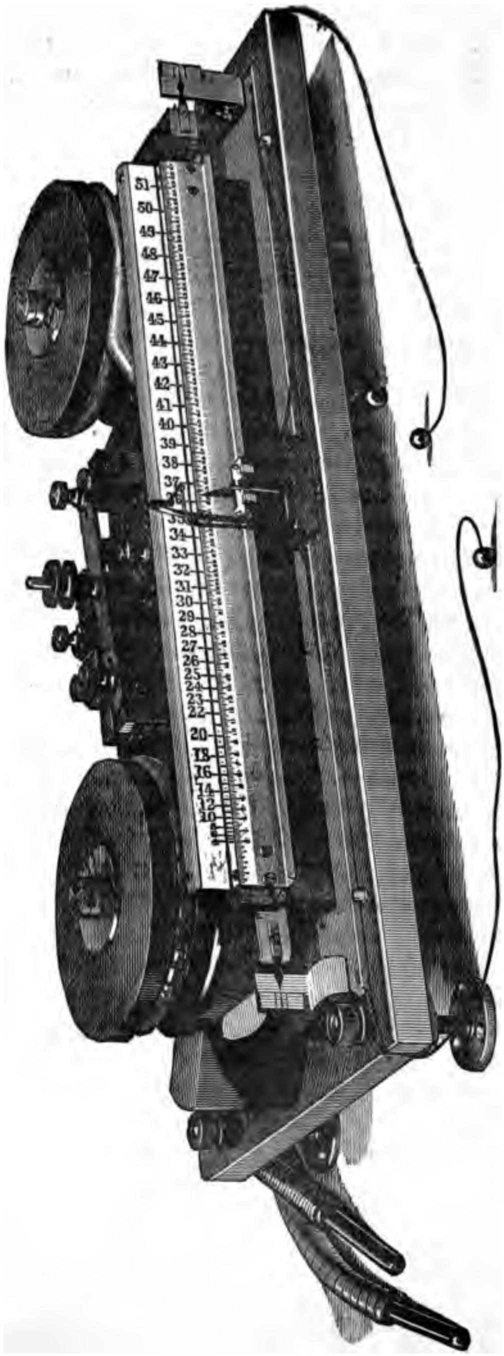

Fig. 14.—Deka-ampere Balance.

by one of the fixed rings and repelled by the other. The position of the movable ring equidistant from the two fixed rings is a position of minimum force, and the sighted position, for the sake of stability, is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the attracting ring by such an amount as to give about $\frac{2}{10}$ per cent. more than the minimum force. In the balance instruments to measure alternate currents (which may be also used for direct currents) of from 1 ampere to 600 amperes, the main current through each circle, whether of one turn or of more than one turn, is carried by a wire rope of which each component wire is insulated by silk covering, or otherwise, from its neighbour, in order to prevent the inductive action from altering the distribution of the current across the transverse section of the conductor.

§ 48. The balancing is performed by means of a weight which slides on an approximately horizontal graduated arm attached to the balance; and there is a trough fixed on the right-hand end of the balance into which a proper counterpoise weight is placed, according to the particular one of the sliding weights in use at any time. For the fine adjustment of the zero a small metal flag is provided, as in an ordinary chemical balance. This flag is actuated by a fork, having a handle below the case outside. To set the zero, the left-hand weight is placed with its pointer at the zero of the scale, and the flag is turned to one side or the other until it is found that, with no current going through the rings, the balance rests in its sighted position. To measure a current, the weight is slipped along the scale until the balance rests in its sighted position. The strength of the current is then read off approximately on the fixed scale (called the inspectional scale), with aid of the finely-divided scale for more minute accuracy, according to the explanations given below. Each number on the inspectional scale of the ampere balances is twice the square root of the corresponding number on the fine scale of equal divisions. In the watt-balances the numbers on the inspectional scale correspond to those on the fine scale. The slipping of the weight into its proper position is performed by means of a self-releasing pendant, hanging from a hook carried by a sliding platform, which is pulled in the two directions by two silk threads passing through holes to the outside of the glass case. Four pairs of weights (sliding and counterpoise), of which the sledge and its counterpoise constitute the first pair,

are supplied with each instrument. The weights are adjusted in the ratios of 1 : 4 : 16 : 64, so that each pair gives a round number of amperes, or half-amperes, or quarter-amperes, or of decimal sub-

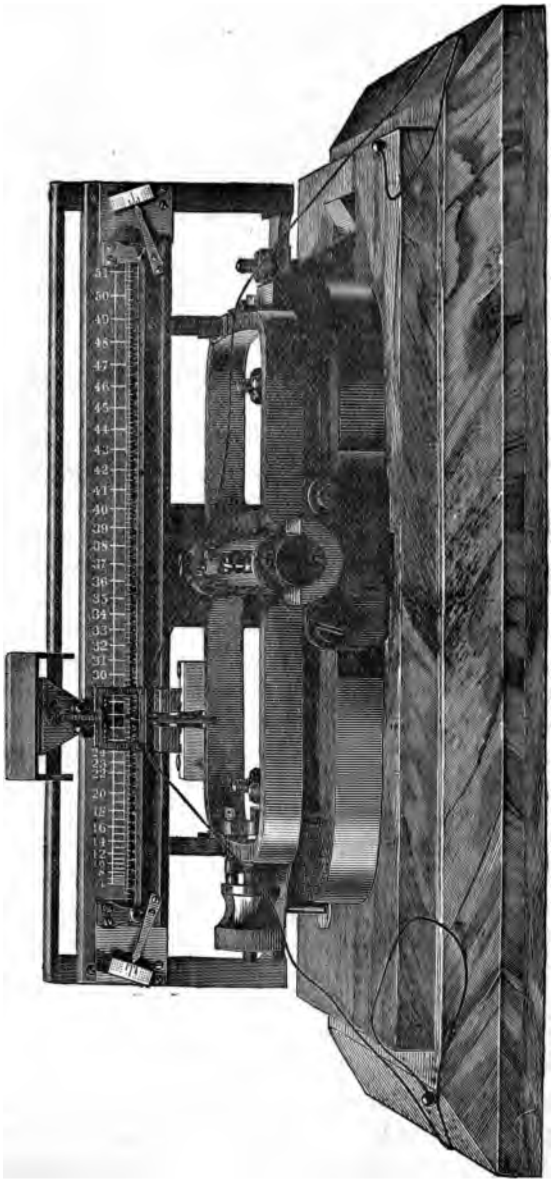

FIG. 15.—Standard Kiloampere Balance.

divisions or multiples of these magnitudes of current, on the inspectional scale. The useful range of each instrument is from 1 to 100 of the smallest current for which its sensibility suffices. The ranges of the different types of this instrument regularly made are—

I.	Centi-ampere	balance	from	1 to 100 centi-amperes.
II.	Deci-ampere	,,	,,	1 to 100 deci-amperes.
III.	Deka-ampere	,,	,,	1 to 100 amperes.
IV.	Hekto-ampere	,,	,,	6 to 600 amperes.
V.	Kilo-ampere	,,	,,	25 to 2,500 amperes.
VI.	Composite	,,	,,	02 to 500 amperes.

and from 100 to 50,000 watts (at 100 volts).

VII. Deci-watt balance, to suit currents from 0·1 to 20 amperes.
VIII. Deka-watt balance, to suit currents from 0·5 to 100 amperes.
IX. Hekto-watt balance, to suit currents from 5·0 to 500 amperes.
X. Kilo-watt balance, to suit currents from 25·0 to 3,000 amperes.
XI. Kilo-watt balance, to suit currents from 100·0 to 10,000 amperes.

N.B.—The ampere balances are designed to carry 75 per cent. of their maximum current *continuously*, and carry their maximum current long enough for all standard purposes.

The following table shows for each type of instrument the value per division of the inspectional scale corresponding to each of the four pairs of weights:—

	I. Centi-amperes per division.	II. Deci-amperes per division.	III. Amperes per division.	IV. Amperes per division.
1st pair of weights,	·25	·25	·25	1·5
2nd ,,	·50	·5	·5	3·0
3rd ,,	1·0	1·0	1·0	6·0
4th ,,	2·0	2·0	2·0	12·0

§ 49. The fixed inspectional scale shows approximately enough for most purposes the strength of the current; the notches in the top of the aluminium scale show the precise position of the weight corresponding to each of the numbered divisions on the fixed scale, which practically annuls error of parallax due to the position of the eye. When the pointer is not exactly below one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side, to the space between two divisions, may be estimated inspectionally with accuracy enough for almost all practical purposes. Thus we may readily read off 34·2 or 34·7 by estimation with little chance of being wrong by 1

in the decimal place. But when the utmost accuracy is required the reading on the fine scale of equal divisions must be taken, and the strength of current calculated by aid of a table of doubled square roots. Thus, for example, if the reading is 292 we find 34·18, or, say, 34·2 as the true scale reading for strength of current; or, again, if the balancing position of the pointer be 301 on the fine scale, we find 34·70 as the true reading of the inspectional scale.

The centi-ampere balance, with a thermometer to test the temperature of its ampere rings, and with platinoid resistances up to 1,600 ohms, serves to measure potentials of from 10 volts to 400 volts.

CONSTANT OF THE CENTI-AMPERE BALANCE WHEN USED AS A VOLTMETER.

Weight used.	Resistance in circuit.*	Volts per division of fixed scale.
First pair of weights,	400	1·0
,,	800	2·0
,,	1,200	3·0
,,	1,600	4·0

If the second pair of weights is used, the constants will be double of those noted above.

COMPOSITE BALANCE.

§ 50. This instrument is similar in form to the centi- and deci-ampere balances, but the pair of fixed coils at one end of the beam are made of a rope of insulated wires similar to that used for the coils of the hekto-ampere balance. Separate electrodes are provided for the rope coils, and for the fine-wire coils. A switch which allows the movable coils either to be included in the circuit by themselves or in series with the fixed fine-wire coils is attached to the underside of the sole-plate of the instrument. When the handle of the switch is turned to "Watt," the movable coils alone are in the circuit; but when the handle is turned to "Volt," both the movable and the fixed fine-wire coils are in the circuit. The composite balance can be used as hekto-ampere balance, or as a wattmeter, or as a voltmeter, by following the instructions given below. To enable the composite balance to be used as a direct-reading wattmeter or voltmeter, a separate anti-inductive resistance of platinoid wire, subdivided into four coils,

*Including resistance of the instrument, which is about 50 ohms.

is usually supplied. The first coil is equal to the resistance of the fixed fine-wire coils, and is intended to be included in the circuit of the movable coils when the instrument is used as a wattmeter. The second coil is arranged to make up 200 ohms with the resistance of the fine-wire movable and fixed coils. The third coil is 200 ohms, and the fourth is 400 ohms. It is not advisable that the current through these resistances should be allowed to exceed 0·5 ampere.

Standard Watt Balances.

§ 51. The main use of the watt balance is to measure the true energy developed in an inductive alternating-current circuit. The balances are, except those described below, similar in form to the standard ampere balances, but the movable coils are, as in the case of the composite balance, wound with fine wire. These coils are of low resistance, and are joined up in series with a large anti-inductive resistance in a "potential circuit" across the mains, while the fixed coils carry the whole current in the circuit to be measured, and are inserted in one main. The instruments are provided with weights similar to those used with other balances, and a certificate is given stating the number of watts per division for each weight.

Electric Watt Balance for the Measurement of Currents up to 10,000 Amperes.

§ 52. These instruments were designed in the first instance to meet requirements for a standard balance to read up to 10,000 amperes. For this purpose it was not considered advisable to use the ordinary idiostatic "Kelvin" balance on account of the necessarily enormous proportions which the movable beam would have, and the consequent limitation of range due to possible stiffness in the suspending ligament. The instrument was therefore designed on the wattmeter plan, in which the main current passes through heavy copper conductors, while a small current of measured amount is passed through two coils of fine wire at each end of a movable beam in every way similar to that of the centi-ampere balance. The main conductor is shaped like a double rectangle, and the current is conducted in by one electrode round three sides of the top rectangle then down by a connecting-piece

round three sides of the bottom rectangle and out by other electrode. The beam, with its movable fine-wire coils, is situated between the two rectangles, and its terminals are brought to two binding screws. The action when the current is passing is the same as in the other electric balances—viz., the right-hand coil on the beam is attracted and repelled up by the current passing through the fixed conductors above and below, and the left-hand coil is similarly repelled and attracted down, the resulting force being balanced by the sliding along of a weight on a graduated scale. The conducting rectangles are each made of a thick copper plate, with a slot about 0·5 cm. wide cut from the right-hand side up to within 9 cm. of the left-hand end.

§ 53. The instrument is, of course, a self-contained wattmeter, and when it is to be used as such, extra resistances are provided for the fine-wire circuit. The resistance of the fine-wire coils is about 10 ohms, and the extra resistances provided are subdivided into coils of 400 ohms each so as to permit of an adjustment of the instruments constant from 50 to 2,000 watts per division of the scale. When the instrument is used as a standard ampere balance, the current values can be obtained by dividing the watt readings by the E.M.F. if a reliable voltmeter is available, but for very accurate working it is best to measure the actual current passing through the fine-wire coils on an auxiliary instrument, such as a centi-ampere balance. By this method great sensibility can be obtained, as currents up to one ampere can be used, and so the constant of the instrument can be varied at pleasure from 0·1 ampere to 10 or 20 amperes per division of the scale, and thus a range of measurement from 0·1 to 10,000 amperes is provided. The balance, as described above, is intended for use with continuous current, and it is evident that an instrument of this kind, if used with alternating current, would require a special constant to suit different periods of alternation.

§ 54. To suit cases where the testing is either on direct or alternating systems, a different type of instrument with a stranded main conductor is made. The main conductor is of U-shape, and passes under the movable coils. This conductor is made up of ropes of insulated copper wire, twisted together so as to form a cable with a hollow core. In order to correct any effect due to the induction of one arm of the coil upon the other the twisting

Fig. 16.—Alternate-Current Kilowatt Balance.

is done in a very careful manner, so that the strands of the cable which are inside on passing the left-hand movable coil on one side are outside on passing the right-hand movable coil on the same side, and are in the reverse direction on the other arm of the U. The core of the cable is, as mentioned above, hollow, and brass tubes are passed up each arm of the U as far as the bend. The main object of these tubes is to prevent any deformation in the cable, but they also serve as a means of blowing air through to keep the conductor cool, if it should ever be necessary to use it for much heavier currents than those for which the instrument is primarily intended.

SPECIAL STANDARD BALANCES.

§ 55. When very great accuracy and permanency is required, as in the case of balances used as ultimate standards of current in laboratory work, a modification is made in the ordinary ampere balances. The scale and sliding weights are taken away, and the beam is made specially strong, and has a pointer at each end, situated at the middle of the coil. A scale pan is hung at each end of the beam, and the distance from coil to coil is greater than in the ordinary balance. An arrangement of screws is also provided by which the beam can be raised to its original position should the ligaments from any cause have been stretched.

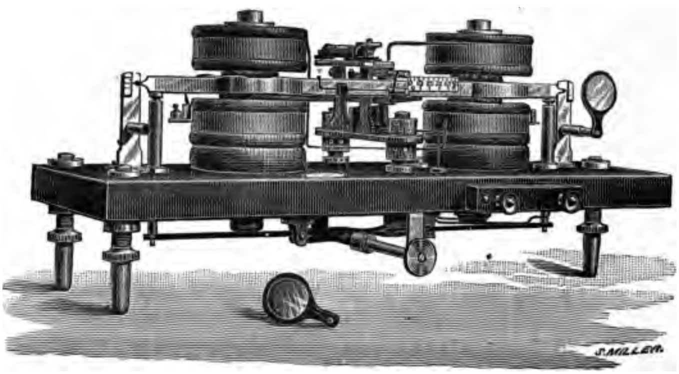

FIG. 17.—Standard One-ampere Balance.

§ 56. The method of making an observation is as follows:—A weight of fixed amount is placed on the left-hand scale pan, and the beam is balanced with no current through the coils; the weight is

then lifted to the right-hand scale pan, and the current is made. The amount of current passing is adjusted till the beam again balances, and according to the value of the weight used, the strength of current is known within a very small percentage of accuracy. A one-ampere standard balance of the type supplied to the Board of Trade is shown in Fig. 17.

NEW ENGINE-ROOM WATTMETER.

§ 57. The new engine-room wattmeter has a main circuit formed of a double rectangle of copper rod having sufficient area to carry 200 amperes, and a shunt circuit with two fine-wire coils astatically arranged. The main coil is mounted on a slate back so that the rectangles are horizontal. The shunt coils are mounted on a light but strong aluminium frame. One end of this frame has a circular knife-edged hole fixed to it, and the other end has a straight knife-edge. These two knife-edges rest on two phosphor-bronze hooks attached by insulating supports to the outside ends of the double rectangle. By this method of suspension complete freedom from friction is obtained, while the movable system is kept in a definite position without end guides. Each fine-wire coil has about a 1,000 turns of insulated wire, and its resistance is about 100 ohms. The current is conducted in and out from the movable system by two flat palladium spiral springs, which also supply the restoring force for governing the sensibility of the instrument. Not more than one-twentieth of an ampere is allowed to pass through the fine-wire circuit, and, in order to regulate this, a large non-inductive resistance is rolled on the case of the instrument, which offers a large cooling surface. The scale has nearly uniform divisions, and is graduated to read directly in watts or kilowatts as required.

IMPROVED RHEOSTAT.

§ 58. The object of the rheostat, invented over 40 years ago by Wheatstone, is to provide an electric resistance which can be varied continuously. The original instrument, although admirable in conception and commonly shown on the lecture table, has been but little used on account of practical defects. The new instrument (Fig. 18) is an improved form of Wheatstone's rheostat, in which the wire is guided from one cylinder to the other by a fork carried along through the requisite range by a nut travelling on a long screw-shaft. This screw-shaft carries a toothed wheel, which

turns the two cylinders by means of toothed wheels attached to their shafts. A watch-spring, as in Jolin's improvement of Wheatstone's rheostat, keeps the wire always tightened to the proper degree. A leather buffer at each end of the range of the nut acts as a guard against overwinding in either direction.

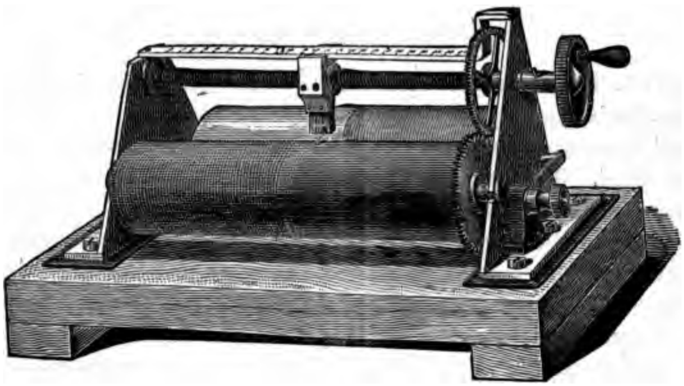

FIG. 18.—High-Resistance Rheostat.

The conducting cylinder and the wire are both of platinoid, a metallic alloy having properties which make it specially suitable for the purpose. It has very high electric resistance, very small temperature variation of resistance, and its surface remains almost or altogether untarnished in the air. On account of the last-named property, the contact between the wire and the conducting cylinder, and continuity in action, which was a great difficulty in the old form of apparatus, is very complete.

LOW-RESISTANCE RHEOSTAT.

§ 59. The conducting cylinder in this instrument is made of brass, nickel-plated so as to avoid tarnishing, and the wire used is copper, also nickel-plated. The rheostat can be supplied to carry currents as high as 30 amperes. Five different types of the instrument are made, viz. :—

	Wire.	Approximate resistance.	Maximum current.
Type I. ...	Platinoid ...	600 ohms ...	0·2 amperes
,, II. ...	,, ...	100 ,, ...	1·0 ,,
,, III. ...	,, ...	100 ,, ...	2·0 ,,
,, IV. ...	,, ...	10 ,, ...	5·0 ,,
,, V. ...	Copper ...	0·5 ,, ...	30 ,,

C (IV.).—RECORDING AND INTEGRATING INSTRUMENTS, §§ 60-61.

Recording Voltmeter.

§ 60. This instrument is of simple construction, and consists of a long solenoid, giving a very intense field, into which the upper end of a long soft-iron plunger is entered. The plunger is suspended on a set of spiral springs, and carries on its lower end a pen of special construction. A drum, round which a record paper is fixed by a metal band, is revolved by means of a clock inside it,

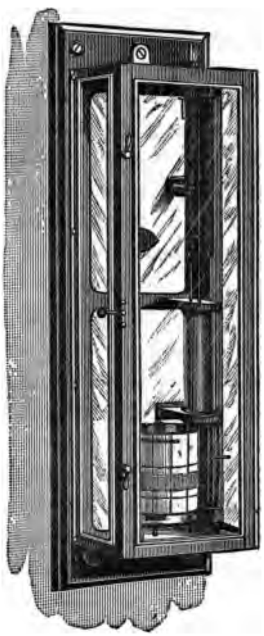

Fig. 19.—Recording Voltmeter and Amperemeter.

making one revolution in 12 or 24 hours. The pen rests against the paper with a small component of its own weight, and as there are no pivots or other multiplying gear, the instrument is free from frictional error. Owing to the fact that the magnetic field of its own coil is very intense, the instrument is found to be

free from the effects of board currents or other stray field. In changing the paper, the whole drum can be lifted out, allowing the changing to be done with ease, and at the same time the pen can easily be got at for renewing the ink. The scale is a wide-division one at the working part, and is divided in volt divisions. The calibration of the instrument is quite permanent. Amperemeters are made on the same plan and have equal division scales from 0 to maximum.

ELECTRICITY SUPPLY METER, 1898 PATTERN.

§ 61. This meter is the same in principle as that introduced in 1892, which was then described by Mr. Meikle in his paper read before the Philosophical Society of Glasgow in November of that year. Since then many improvements, the result of experience in actual use, have been introduced. In the new meter the driving mechanism, or clock, if it may be so called, is of the simplest possible form. It consists of a drum and scape wheel, both fixed rigidly to the same spindle; also on that spindle is an arm free to move round it, having pivoted eccentrically on its other end a sector of steel bearing against the drum on its outer edge and arranged to lock with and drive the drum round when pulled up, but free to run in the opposite direction without carrying the drum round with it. Attached to the end of this lever, and passing over the drum, is a band of flexible material (an ordinary mohair bootlace) connected at the other end with an iron rod about 12 cm. long and 0·8 cm. diameter, which acts as the driving weight. This weight is arranged to have a travel of 4 cm., and when it has fallen that distance a disc of insulating fibre on its lower end presses down a light brass slider and makes a contact between two pieces of platinum, sending a current of a tenth of an ampere round a solenoid, into which the upper end of the iron driving weight is entered. The weight is immediately sucked up to the top of its range, the arm carrying the steel eccentric falls back on the drum, and the fibre disc catches the small contact slide at the top and breaks the current passing round the solenoid, allowing the weight to start on its travel downwards, carrying the drum round. The whole action takes place in the fraction of a second; the energy used is therefore very small. To prevent sparking at the contact, a shunt of very high resistance is fitted in parallel with the winding solenoid, the current induced at

breaking passing round this, instead of jumping across the break of the contact. The contact is a sliding one, and should the circuit not be completed at the usual point, either through wear, the intervention of dust, or any other cause, it will be pushed on further till a contact is made, this sliding cleaning the platinum surfaces and keeping them in good order. The speed of the clock is controlled by means of a pendulum, and it is found to keep time with an accuracy well within $\frac{1}{4}$ per cent., whether running idle or when the meter has full load on. The clock is self-starting, and should the current be switched off from the shunt solenoid, the driving weight will run to the bottom of its range and make the contact before the clock stops. Immediately the current is switched on the weight is drawn up. The pallets are so designed that the scape-wheel teeth give the pendulum an impulse,

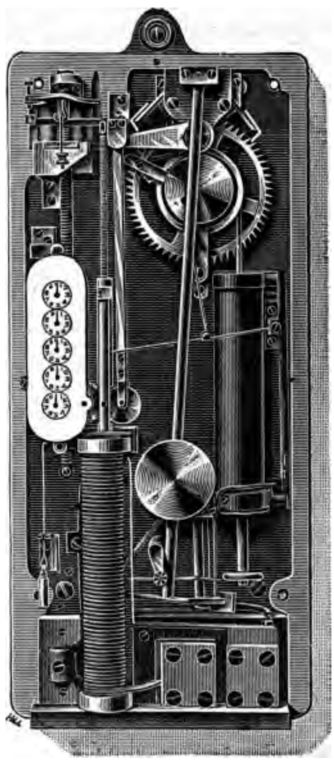

FIG. 20.—Electricity Supply Meter.

and the clock starts off. In Fig. 21, the electrical part of the meter is shown. A long solenoid of wire, or copper ribbon, sufficient to carry the maximum current for which the meter is intended, has its ends connected to the main terminals. This solenoid has entered into it a soft-iron plunger, 16 cm. long and 1·2 mm. diameter, suspended from a spiral spring of phosphor-bronze wire. This spring is in turn supported on the end of a small balance arm, the action of this being partly controlled by gravity and partly by means of a small flat spring adjusted to the required position by screws below it. The action of this combined suspension is to allow the plunger to be drawn into the solenoid by an amount exactly proportional to the current passing in the solenoid, or so that the displacement for, say, one-half ampere is exactly a twentieth of that for 10 amperes. At the lower parts of the scale, before the iron plunger has reached saturation, the small beam acts alone, controlled by gravity; next, it touches the small flat spring, this being so regulated by means of the adjusting screw below it that the deflections are proportional to the current, a shorter length of spring coming into use as the beam is pressed down, till with a current sufficient to saturate the iron the beam comes on a stop screw, and the spiral spring is alone in use. So that these vertical displacements may be recorded, the plunger passes between two rollers, one of these being geared to the counter and the other carried on the end of a crank lever. At periodic intervals of about one minute the cam, driven at a uniform rate by the clock, causes the plunger to be gripped between the two rollers. Immediately following this motion the lifter begins to rise, lifting the plunger to the zero position, and making a record corresponding to the vertical displacement of the plunger, this in turn being in proportion to the current passing in the main solenoid. The zero position is adjusted that the lifting bar touches the stop and cannot raise the plunger above the zero mark. To allow the plunger to take up its next position, the cam now raises the end of the crank lever resting on it, throwing out the lower end carrying the roller, leaving the plunger free. The lifter bar now begins to descend, ready to bring the plunger back when it is next gripped. The whole plunger system is supported on a platform, which can be raised or lowered by means of a screw till the plunger comes to the zero mark. It may be said that an instrument with spiral spring suspension such as is used in this meter will not be permanent in its standardising. With springs

wound with ordinary commercial wire, that would be the case. The springs are subjected to the following severe treatment and tests before being used:—They are wound from selected phosphor-bronze wire. After winding only uniform springs are taken, and

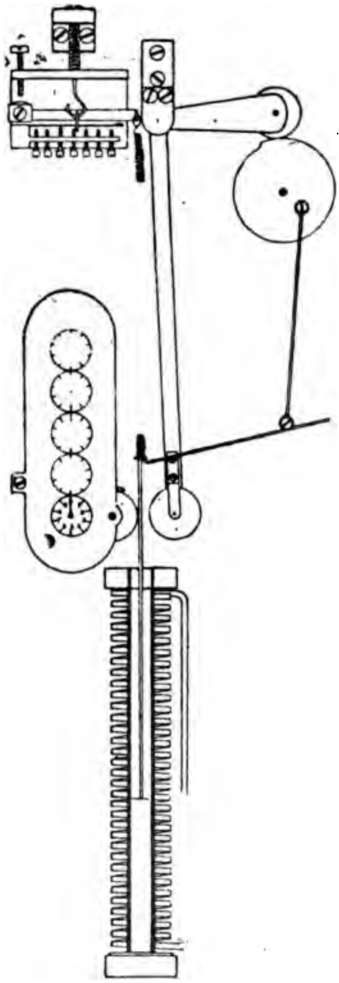

Fig. 21.

these are hung in an oven having a temperature of 70 degrees C., with a weight on the lower end of each corresponding to twice the maximum pull during working. In about four days they are

divided the nerves of one side, and ten days later those of the other side. The animal died seven days later, and on examination the nerves first divided were found united "by a substance having the same colour as the nerve, but not having the fibrous appearance." This, he states, was regeneration of the nerves, "a circumstance never hitherto observed." He thought that, given a longer time for the nerve first cut to regenerate, the animal might survive the division of the nerve of the opposite side; and to prove this he divided the vagus of the right side, also in a dog, and three weeks later removed a portion from the vagus of the left side. The animal recovered perfectly. Eighteen days later he killed it, and found the nerves both united, the cut ends of the right nerve being united by a mass of greater thickness than the nerve, while those of the left were united by a narrower portion.

The results of this investigation were communicated to the Royal Society by Wm. Hunter on 13th June, 1776, but the prevailing opinion being that the nerves were united simply by connective tissue, the paper was not thought worthy of publication until nineteen years later, when its importance was recognised. The preparation, however, was placed in Wm. Hunter's museum, and was the means of stimulating others to further researches. I found this preparation recently in the Hunterian Museum in Glasgow, and was easily able to identify it from the drawing published with the paper. (Plate.)[1]

Fontana,[2] who saw the preparation in Hunter's Museum in 1778, commenced a research on rabbits, particularly with the object of determining whether the mass which reunites the ends of a cut nerve is composed of nerve substance, or is simply cicatricial connective tissue; for he states that it was the latter view which William Hunter took of Cruikshank's preparation. Fontana saw in two of his vagus sections reunion occur, and saw the passage of the nerve fibres, which he had discovered in normal nerve, through the intermediary mass, and concluded that nerve regeneration was possible.

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[1] My thanks are due to Professor Young for his kindness in permitting me to photograph this preparation, and also for many valuable suggestions regarding this paper. The delay in printing Cruikshank's communication until after the death of Hunter accounts for the history of the preparation not having been inserted in the catalogue of the museum.

[2] *Traité sur le venin de la vipère, etc.*, tom. 2, p. 177. Florence, 1781.

Monro[1] soon afterwards found in a frog reunion of the sciatic nerve, which had been divided a year previously, but concluded against reunion by nerve substance, as in his experiment he could not find return of sensation or motion, although the limb did not undergo the slightest trace of atrophy.

Michaelis,[2] who had also seen Cruikshank's preparation, made experiments on dogs, and found, as a rule, regeneration of the portion excised. He made an experiment, the priority of which is usually given to Haighton, to show that the function is not restored by means of anastomosis or supplementary supply, theories which were afterwards brought forward to explain return of function after nerve section. His experiment was performed on a dog, and consisted in excising one inch from the phrenic nerve (? vagus). The animal recovered from this in a few days. One-and-a-half months later he divided the nerve of the left side, and on the third day recut the first nerve, which by this time had reunited. The animal immediately showed the signs of division of both nerves, and died soon afterwards.

Arnemann,[3] who published the results of his experiments soon afterwards, came to the opposite conclusion, as he never found regeneration. He admits the reunion of the ends of a divided nerve, but this is merely by connective tissue, the result of the growth of the nerve sheath and surrounding connective tissue. He admits, however, the possibility of a reunion which allows re-establishment of function, but this is the result of the close approximation of the ends and the absence of inflammation, the nerve current being then able to overstep the slight obstacle. He conducted two experiments on dogs to determine if nerve suture could bring about this favourable result, but, due doubtless to the want of antiseptic precautions, his results were so disastrous that he thought nerve suture an unjustifiable operation.

Similar results, unfavourable to the view of the possibility of regeneration of nerves, had been obtained by several other workers after Arnemann, when Haighton[4] commenced his experiments. He followed the same method of investigation as

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[1] *Observations on the Structure and Functions of the Nervous System*, p. 81. Edinburgh, 1783.

[2] After Arnemann. *Versuche über die Regeneration an lebenden Thieren.* Göttingen, 1787.

[3] *l.c.* [4] *Phil. Trans.*, 1795, I., p. 190.

Cruikshank, and states that the differences of opinion, which then existed, depended on the fact that there was difference of opinion as to the normal structure of nerves, and that, until this was known, the only way to settle the matter was to take the physiological proof. He therefore repeated Cruikshank's experiments. He first divided both vagi and sympathetic nerves in a dog, and death ensued on the following day. Next he divided the vagus and sympathetic of one side, also in a dog, and six weeks later divided the nerves of the opposite side. In a month the dog had recovered, and at six months was as well as before the operation. He explained this as due to the reproduction of the cut vagus in the six weeks; and the gradual improvement in the dog's condition he explained as the result of the gradual restoration of the nerve which had been cut at the second operation, together with the gradual further improvement of the nerve first cut. The dog was kept for nineteen months, and was used as a "yard dog." At the end of that time, wishing to prove that the result was really due to nerve regeneration, he divided the nerves of both sides again, above the points of previous section, and the animal died on the following day. This experiment resembled that conducted by Michaelis, who, however, allowed his dog to live only three days after the division of the second nerve.

Haighton did not attempt to prove the regeneration of nerves anatomically, and it was scarcely possible that this could have been done satisfactorily by the microscope at that time, but, two years later, J. C. H. Meyer[1] published the results of his investigations, which had been conducted by a new method. Reil had shown that nerve tissue resists the action of nitric acid, while the connective tissue is destroyed, and Meyer took this test to settle the point whether functional return is accompanied also by anatomical regeneration. Arnemann's statement that the nerve current could spring across a slight barrier had, of course, not been refuted by the experiments of Haighton. Meyer, then, found, in the peripheral nerves of the dog, that, in little over a month, function returned after section. When the restored nerves had been subjected to the action of nitric acid, nerve substance was left not only in the bulbs formed at the cut surfaces, but formed a string of nerve substance passing across

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[1] *Reil's Archiv f.d. Physiol.*, Bd. 2, 1797, S. 449.

between the two ends. Another experiment made by him is of importance, as tending to show the regeneration of nerves which have been cut off from their centres in the spinal cord and ganglia. He cut the tibial, and, thirteen days later, the sciatic, and, when examined at the end of sixty-eight days, the tibial was found united by a strand of nerve substance, and the sciatic was not united.

The balance of opinion was still against the possibility of nerve regeneration, and it was thought that Haighton might have mistaken the nerves which he cut for the vagi.[1] Prévost,[2] therefore, repeated Haighton's experiments on five kittens, in each of which he first resected two-and-a-half lines from the left vagus. The right vagus he cut, in one at the end of a month, death resulting in fifteen hours; in another, at the end of two months, ending fatally in thirty-six hours; and in two, at the end of four months, and in fourteen days both cats were well. To prove that the recovery was not due to anastomosis, he then cut the right vagus above the point at which it had previously been cut, and the animal remained well. The left vagus he recut in thirty-six hours, and death resulted in thirty hours. He then submitted the reunited nerve to microscopical examination, and states that he saw the passage of nerve fibres through the intermediate mass from one end to the other.

The doubt which some still held of the possibility of nerve regeneration seems to have been finally dispelled by the work of Otto Steinrück,[3] published in 1838. He conducted fifty experiments on frogs and rabbits, chiefly on the sciatic nerve, but in some cases on the vagus, infraorbital, and hypoglossal, in some cases simply dividing, and in others resecting a portion. He allowed many of the animals to live a long time, until sensation and motion were perfectly restored. He concludes that, under favourable conditions, reunion of the divided nerve occurs, first, by a connective tissue bond, in which ultimately are developed new fibres, which differ from the old neither in physical nor in chemical properties. The health of the animal must be fairly good, and the surrounding conditions favourable, and the time taken for the restoration of function varies from five weeks to one or two years,

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[1] *Vide* Magendie. *Journ. de Physiol. Expériment.*, 1821, tom. 1, No. 2, p. 120.

[2] *Froriep's Notizen*, Bd. 17, No. 360, 1827, S. 113.

[3] *Schmidt's Jahrbücher*, Bd. 26, 1840, S. 102.

and he notes that sensation usually returns before motion. He found that the new fibres formed in the uniting mass are produced both from the central and from the peripheral segments of the nerve.

The chief difficulty in deciding for or against the possibility of reunion of a divided nerve by means of true nerve substance, hitherto lay in the fact that the anatomy of the normal nerve fibre was not perfectly known. But this defect was now remedied by the discovery by Remak in 1837 of the "*primitiv Band*," confirmed two years later by Purkinje, and called by him the axis-cylinder, and by the discovery by Schwann in 1839 of the "membranous sheath," now called the sheath of Schwann. From this time onwards investigations on the subject were of a more precise character. Hitherto the observations made had been directed only to the determination of the possibility of a divided nerve being functionally restored by reunion by means of nerve substance, and from the time of Steinrück, with few exceptions,[1] the possibility has been confirmed by all observers.

But with Nasse[2] a new subject of study was begun, namely, the changes which ensue in the nerve after division, and before restoration has commenced. This author studied the changes which ensued at the point of section in the sciatic in frogs and rabbits, and found that after section destruction of the primitive fibres took place, the fibre breaking up into cylindrical portions, ending in fatty degeneration with absorption, ultimately the whole fibre, including the sheath of Schwann, disappearing. He also found that the new fibres are smaller than the old and of different appearance.

Günther and Schön[3] in the following year corroborated Nasse's discovery, and considered this change in the structure of the nerve as the cause of the speedy loss of conductivity in the distal segment of a divided nerve, and viewed the degenerative changes as the result of lowered vitality by the separation of the nerve from the centre. They found also that the distal segment of a divided nerve, which has lost its irritability and normal structure, can, if not too long separated, reunite with the proximal end, and regain its structure and functions, and they regarded this reunion as effected from both the proximal and distal segments.

[1] *Vide* HUTIN. *Mémoires de l'Acad. Impér. de Méd.*, tom. 19, 1855, p. 467.

[2] *Müller's Archiv*, 1839, S. 405.

[3] *Müller's Archiv*, 1840, S. 270.

These observations on the degeneration of the distal segment were corroborated by Stannius,[1] who was the first to make the observation that the degenerative changes are not confined alone to the immediate neighbourhood of the wound, nor even to the main distal stem, but that even the finest ramifications of the nerve in the muscular fibres show signs of the degenerative process. But this was only an isolated observation, and he gives it as such, without regarding it as proved to be a general law. His observations were made on toads and frogs, and he found that the loss of irritability of the distal segment took about eight-and-a-half days to become complete, and that the loss took place centrifugally.

These earlier observations on degeneration of nerves were taken up by Waller[2] in 1849. He proved that the degeneration observed by Nasse is not confined to any limited section of the distal segment of a divided nerve, but that it extends to the ultimate ramifications. His observations were made principally on frogs, in which he had divided the glossopharyngeal nerve of one side. The animals were allowed to live from one to four months, and, at increasing intervals from the time of section, he examined the state of the terminal ramifications in the fungiform papillæ of the tongue. By snipping off the papillæ by means of sharp scissors, he was able to examine the microscopical appearance of the nerve endings in the living state. He also examined the degenerative process in his own tongue by applying a ligature round the base of a papillà, and snipping off the latter at the end of the third day. By these observations, and by examining also the distal stem of the glossopharyngeal in the frog, and the distal segment of the divided sciatic in rabbits, Waller showed that degeneration after section of a nerve extends from the point of section onwards to the ultimate ramifications. He also found that the central segment of the nerve remained unaltered. Pursuing his investigations further, he showed that, on dividing both roots of a spinal nerve above the ganglion on the posterior root, none of the sensory fibres below the point of section degenerate, while the motor do; and of the portions of the roots above the point of section the posterior degenerates, while the

[1] *Müller's Archiv*, 1847, S. 443.

[2] *Phil. Trans.*, 1850, II., p. 423. *Compt. Rend. de l'Acad.*, tom. 33, p. 606; tom. 34, pp. 524, 582, 675, 842, 979. *Müller's Archiv*, 1852, S. 392. *London Journ. of Med.*, vol. 4, 1852, p. 609.

anterior remains normal. On dividing the posterior root below the ganglion, and leaving the anterior root intact, he found that the sensory fibres below the point of section degenerate, while the motor remain intact. Thus Waller was led to establish the law of dependence of the nerves on trophic centres, which, he showed, lie for the motor fibres in the spinal cord, and for the sensory in the ganglion on the posterior root, and to show that the degeneration resulting in the nerve fibre after section depends upon its separation from its trophic centre. He gave this also as a new method for the study of the nervous system, and was able to trace by its means the ramifications of the ultimate nerve fibres in the frog's tongue. He cut one glossopharyngeal, and showed by the ultimate degeneration that some of its fibres cross the middle line into the region supplied by the nerve of the opposite side, and also showed the existence of anastomosis with the hypoglossal nerve.

He divides degenerative changes into three periods—the first being found in frogs in summer at the end of four or five days, at which period the intratubular contents of the papillary fibres are interrupted by transverse lines, and notes that this stage can only be accepted as a degenerative change by examining living fibres, and comparing with the normal papillary nerves of the opposite side of the tongue, as similar changes are produced in perfectly normal nerves *post mortem*, or by treatment with reagents. His second period is developed by ten days, and then the tubes are filled with round or oblong masses, as if the contents had divided into two constituents. In the third period the tubes are filled with black granules, which resist the action of acids and alkalies. These are ultimately absorbed, leaving the nerve composed simply of collapsed membranous sheaths, resembling strands of connective tissue, having still here and there remains of the black granules. The axis-cylinder is not expressly mentioned by Waller, but as he refers to the whole intratubular contents, he evidently means that this structure disappears along with the medullary sheath. Budge,[1] who had worked partly in conjunction with Waller, came to the same conclusions.

According to Waller, the old fibres never recover their functional activity or structural characters, and reproduction of the nerve after section occurs, not only in the intermediate portion

[1] *Zeitsch. f. wissensch. Zool.*, Bd. 3, 1851, p. 347.

uniting the cut surfaces, but also throughout the distal segment to the ultimate ramifications. In frogs, in which the glossopharyngeal had been divided three to four months previously, he found that, while the papillary nerves contained tubes in the third period of degeneration, there were also newly formed fibres lying between the old. These new fibres he found much narrower ($\frac{1}{4}$-$\frac{1}{8}$) than the original fibres, pale, with no double contour, of unequal diameter, with fusiform nuclei at intervals, and closely resembling the fibres in the young frog, just after the tadpole stage. He holds these fibres to be new formations, as they always lay among the old fibres, never within them. He found that these new fibres were developed centrifugally, as they became more numerous as higher levels of the nerve were examined; and they are also dependent upon reunion, as they were never seen until the intermediary portion contained new fibres. At the end of nine months almost all the papillæ contained new fibres.

Waller's view, then, is that the result of section of a nerve is inevitable destruction of the nerve fibres throughout the distal portion; and that regeneration only occurs when the distal segment becomes connected to the proximal; and that the formation of new fibres begins after the old are degenerated, starts in the intermediate portion, and travels on to the ultimate ramifications; these being found in the frog to contain regenerated fibres at the end of nine months.

This view of regeneration was widely accepted, and the first publication to throw doubt upon it was that of Paget[1] in 1853. In this publication he gives an account of two cases of restoration of function after division of the nerve, effected so speedily that there was scarcely time for the process described by Waller to have occurred. The first case was that of a boy, in whom the median and radial nerves had been divided a little above the wrist. The nerves were not sutured, and yet function, which had been totally lost directly after the injury, began to return in the median distribution in ten days, and was nearly perfect in a month. The second case was that of a boy whose hand had been almost severed from the forearm at the wrist, the median and radial nerves being divided. Sensation began to return in from ten to twelve days, although no sutures were employed. These cases

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[1] PAGET, JAMES. *Lectures on Surgical Pathology.* London, 1853, vol. i., p. 282.

Paget gives as examples of healing "by immediate union, or by primary adhesion with an exceedingly small amount of new substance." He accepts the process described by Waller for cases in which such early union fails.

These clinical observations were supported by Schiff,[1] who made his observations on cats and dogs. He admits fatty degeneration of the whole distal segment of the nerve, but differs from Waller in that he maintains that the sheath of Schwann and the axis-cylinder remain unaltered. In the axis-cylinder, even after four months without reunion, he could find no change microscopically or in response to reagents, although the portion of nerve was no longer irritable. He thinks that Waller's new fibres were simply the old, deprived of the medullary sheath; in fact, old fibres at the ultimate stage of their degeneration; and that the fusiform nuclei were simply the nuclei of the old fibres, made visible by the removal of the myeline. Schiff, like Paget, saw recovery of function after seven to thirteen days, and believes that the new fibres are the old, restored by reaccumulation of the myeline. In experimental division of the lingual and infraorbital nerves, where he examined the distal portions in from three to four weeks, he found many of the fasciculi which contained only restored fibres without any trace of degenerated fibres; and in other cases, tracing the restored fibres, he saw that, at intervals, traces of the degenerated myeline remained.

Bruch[2] supports the Wallerian doctrine of degeneration, but holds that the change is a kind of coagulation, similar to that which occurs after death. He never saw simple fatty degeneration, and in this he is supported by most of the later writers. But, like Schiff, he holds that the change in the fibre can be compensated for, with return of function and structure in the old fibres, if reunion occurs. A cat, in which he had divided the sciatic, had recovered function perfectly, and, on examining the seat of section four months after the operation, he found, to the naked eye, no trace of cicatrix, and it was only on stretching the nerve that the seat of section was seen. Microscopically he found here that the fibres above and below were normal, and that at the seat of union there was on each a slight constriction on the sheath of Schwann. The axis-cylinders were continued across, and the

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[1] *Compt. Rend. de l'Acad.*, tom. 38, 1854, p. 448.
[2] *Zeitschr. f. wissensch. Zool.*, Bd. 6, 1855, S. 135.

only difference was that the medullary sheath at this spot was more transparent. He inclines to the view that primary union can occur.

An important paper was published in the following year by Lent,[1] in which he admits the fatty degeneration change, but holds that the empty sheaths of Schwann are left with their nuclei, which were previously hidden by the myeline. He notes with Schiff that there are two kinds of degeneration—one the immediate result of trauma, affecting both the central and peripheral ends, and the other paralytic, due to the separation from the centres, affecting the whole peripheral segment, and leaving this ultimately composed simply of the collapsed sheaths of Schwann with their nuclei. The paralytic degeneration begins in the whole peripheral segment down to the last ramifications simultaneously, but proceeds more rapidly in the finer twigs. He thinks, with Schiff, that Waller's new fibres were simply the old empty sheaths, and traced the degenerative steps up to this point; and holds that it was accidental that Waller did not see them till new fibres were formed in the intermediary portion. He maintains that the old fibres become gradually restored after reunion is effected. He found that in the process of reunion, at both the central and peripheral ends, the nuclei of the old fibres proliferate, and the sheath with its nuclei extends into the intermediary mass, and when reunion is complete the mass contains medullary fibres; but he does not know how the formation of the myeline and axis-cylinder here occurs. He does not agree with Schiff that the axis-cylinder is retained in the distal segment, and holds that in regeneration it is formed anew. He does not agree with Bruch that reunion by first intention can occur. He finds that the regenerated nerve has the appearance of an embryonic nerve at first, the fibres being the old, deprived of their axis-cylinder and medullary sheath, and that, as reunion occurs, the axis-cylinder and medullary sheath are gradually reformed, the most important structure for this reformation being the sheath of Schwann with its nuclei.

Schiff[2] wrote in answer to Lent, maintaining the persistence of the axis-cylinder, which, he states, can always be brought out by treatment with solution of corrosive sublimate. He does not

[1] *Zeitschr. f. wissensch. Zool.*, Bd. 7, 1856, S. 145.
[2] *Zeitschr. f. wissensch. Zool.*, Bd. 7, 1856, S. 338.

agree that there is proliferation of the nuclei of the old sheath at the seat of section, and thinks that the perfect restoration by first intention, described by Bruch and denied by Lent, occurs often.

From the time of Waller's investigations, the view that the distal segment of a divided nerve, in addition to undergoing degeneration throughout its extent as a result of separation from its centres, is incapable of being regenerated until united again to its centres, had been received without contradiction. While confirming the ultimate degeneration as a result of separation, the researches of Philipeaux and Vulpian,[1] published during the year 1859, showed that the regenerative capacity of the distal segment of the nerve is not dependent on a restoration of communication with the centres. As early as 1828 Flourens[2] had published the result of an experiment made to determine whether after section of two neighbouring nerves and cross suture, the proximal segment of the one nerve could unite with the distal segment of the other nerve. In a fowl, in which he had in this way cross sutured the proximal segment of the nerve supplying the under muscles of the wing to the distal of that supplying the upper muscles, and *vice versa*, cross union had been effected, and irritation of the proximal segment of the lower nerve induced contractions in the muscles supplied by the upper nerve, and *vice versa*, thus showing that at least the motor portions of mixed nerves are capable of cross union. Bidder,[3] in 1842, had investigated in dogs the possibility of union of functionally different nerves by suturing the proximal end of a divided hypoglossal to the distal end of the divided lingual, and *vice versa*, but with negative results. Gluge and Thiernesse,[4] in 1859, had repeated Bidder's experiments, and had concluded that the sensory nerve is incapable of becoming united to the motor functionally; but found in the course of their investigations that, after four months of separation from the centres, the distal segment of the nerve was still capable of inducing on irritation strong contractions in the muscles. This Gluge and Thiernesse regarded as irritability of the distal segment retained, not regenerated. Philipeaux and Vulpian, in repeating these experiments on cross suturing, and finding reunion and

[1] *Compt. Rend. de l'Acad.*, tom. 49, 1859, p. 507; tom. 51, 1860, p. 363. *Gazette Méd. de Paris*, tom. 15, p. 420.

[2] *Schmidt's Jahrbücher*, Bd. 5, 1835, S. 94.

[3] *Müller's Archiv*, 1842, p. 102.

[4] *Journ. de la Physiol., Brown-Séquard*, tom. 2, 1859, p. 686.

regeneration in the distal segment of the hypoglossal after suture to the proximal segment of the vagus, wished to find whether the distal segment of the hypoglossal would not have regenerated independently of its connection to the vagus. In one of their experiments (Exp. II.) they resected a portion from the hypoglossal in a dog, and on examination in 84 days no reunion of any kind had occurred; and yet the distal segment contained young regenerated fibres. In other cases (Exp. III.), examined 46 and 47 days after the resection, young fibres were found present, in addition to the remains of the degenerated fibres; and yet reunion had failed. In another experiment (Exp. IV.) the progress of events was well shown. A portion of the hypoglossal having been excised in a dog, the examination was made two months and seven days after the operation, and showed that signs of degeneration were still present, and that regeneration was in its earliest stage. On electrical stimulation no contractions could be induced in the muscles. This animal was allowed to live, and was examined again in four months and 20 days from the time of the original operation. There was still no reunion of the divided ends of the nerve, but now irritation of the distal segment induced strong contractions in the muscles, and microscopical examination showed plentifully new nerve fibres. Similar results were obtained with the distal segment of the divided lingual in the dog, and also with the sciatic and median in the guinea-pig. Thus Philipeaux and Vulpian explained the observation of Gluge and Thiernesse, that the distal segment of the nerve was irritable at four months from the date of separation; for this was not retained irritability, but the nerve had in the interval become regenerated. They found that in from six weeks to six months the distal segment of a divided nerve had undergone complete degeneration, with the exception of a few fibres which retained their normal aspect. These fibres were derived from neighbouring nerves by anastomosis. Thus, in the lingual, there were a few normal among the degenerated fibres, these being derived from the hypoglossal; and in the distal segment of the hypoglossal pain was produced by pinching with forceps, this being the recurrent sensibility discovered by Magendie, and explained later by Claude Bernard[1] as due to

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[1] *Leçons sur la physiologie et la pathologie du Système Nerveux,* tom. 1. Leç. 2 et 3. Paris, 1858.

anastomotic fibres. The regeneration of the distal segment of the nerve, while still remaining unconnected with the proximal segment, might, then, have been due to some influence received from the centres through these anastomotic fibres, or it might have received some influence from the periphery by terminal anastomosis with other nerves. Philipeaux and Vulpian, however, disposed of these objections by an experiment on the lingual nerve of a young dog. A portion was resected from the nerve, and the examination in 46 days showed no reunion, fibres degenerated, and only feeble indications of restoration. For this examination a new portion had been excised, leaving a part of the lingual isolated both from the central and from the peripheral segments. At the end of 38 days more, numerous new fibres were found, not only in the distal segment, but also in the section isolated from both ends, showing thus that regeneration is independent. Thus these authors conclude that nerves, motor, sensory, or mixed, "separated from their centres, may, remaining isolated from their centres, recover their normal structure and physiological properties," and that nerve tissue has an autonomy as other tissues. Although the distal segment of the nerve can thus be completely restored anatomically and physiologically, while remaining separate from the centres, yet they found that reunion is not without its effects. Under the influence of reunion the nerve is regenerated more rapidly than when remaining separate, but otherwise the character of the restoration is the same; and they hold that to regard this hastening of the restoration as due to influence from the centres can only be accepted as a provisional explanation of the facts, pending their true explanation. It is clear, however, that reunion, while not essential to regeneration of young nerve fibres, enables functional activity to be established and exercised at the earliest possible period, and, as it is well known in other tissues that functional activity has an influence in promoting structural perfection, the same explanation may account for the rapidity of regeneration observed by Philipeaux and Vulpian, when reunion had occurred.

These authors also describe the characters of degeneration and regeneration. They hold with Schiff that the axis-cylinder is retained, and that degeneration consists simply in a destruction and absorption of the myeline. The axis-cylinders remain, surrounded by their sheaths of Schwann, which support many

nuclei; probably derived by proliferation from the nuclei of the sheath. Restitution is, then, simply a reaccumulation of the myeline, the new fibres having at first a small diameter, which gradually becomes greater as the myeline accumulates. According to Philipeaux and Vulpian, then, degeneration is not a total destruction of the fibre, but simply an alteration; and reformation is a reaccumulation of the myeline, and is, therefore, not a true regeneration, but simply a restoration. In support of autogenetic regeneration, they found in a later investigation[1] in two cases, that portions of the lingual nerve, transplanted under the skin of the inguinal region in dogs, contained new fibres after six months.

These results which, if true, are of so great importance in surgery, were so much against the view established by Waller, that they were not allowed to pass without severe criticism. While Brown-Séquard[2] gave his assent, and, later, Cornil[3] supported from an experiment of his own, Schiff[4], Landry[5], and Ambrosoli[6] wrote at the time opposing the opinions of Philipeaux and Vulpian, not only on the ground of their own researches, but also from a criticism of their work. Schiff pointed out that the animals upon which they had experimented were all very young, and that, in the earlier periods of life, the nerves are less dependent on their centres in the cord and in the ganglia, and that in the embryo they are so little dependent on the centres in the cord that an embryo in which the cord had not developed, presented the anterior roots of the spinal nerves without pathological change. Ambrosoli explained the results on the same ground, and held that the nerves at an early period possess local nutritive centres; but both Schiff and Ambrosoli held that this independence applied only to the earliest periods of life, and that the results of Philipeaux and Vülpian could not have been obtained in adult animals. Almost all the subsequent writers have opposed the conclusions of Philipeaux and Vulpian, some maintaining with Ranvier that the regeneration which they found was due to connecting strands between the two divided ends,

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[1] *Compt. Rend. de l'Acad.*, tom. 52, p. 849.
[2] *Journ. de la Physiol.*, Brown-Séquard, tom. 3, 1860, p. 160.
[3] *Archives Générales de Méd.*, tom. 19, 1862, p. 81.
[4] *Journ. de la Physiol.*, Brown-Séquard, tom. 3, 1860, p. 217.
[5] *Ibid.*, p. 218.
[6] *Schmidt's Jahrbücher*, Bd. 108, 1860, S. 289.

were not perceived. Thus, there was no sensation of pain on pricking with a pin the palmar aspect of the middle finger; and the sensation of difference of temperature could not be distinguished. On the fourth day after the operation, the sensation of pain began to return obtusely, and temperature differences could be perceived. The case was published on the eighth day, when all the improvement gained had been conserved.

When these two cases were published they gave rise to much discussion. The almost general opinion that to suture a nerve was to run grave risk of producing tetanus, neuritis, and other troubles, and the scanty details given in publishing the cases, induced several workers to begin investigations on animals, with the view of determining the effects of nerve suture. Eulenburg and Landois[1] conducted seventeen experiments on rabbits and dogs, cutting the sciatic, and in other cases the vagus and sympathetic, and suturing with silk, horse hair, or metallic sutures. As a result of their work, they came to the conclusion that, even with perfect coaptation of the nerve and immobilisation of the limb, cut and sutured nerves show in rabbits and dogs no tendency to heal by first intention; that, instead, there was clear evidence of interrupted conductivity at the seat of suture, and loss of function; that the subsequent microscopical examination of the distal segment of the nerve showed that it was degenerated, and that the axis-cylinder shared the fate of the medullary sheath; that in many cases neuritis and perineuritis, suppuration and metastatic processes in the lungs resulted from the employment of the suture; and that, in the absence of details and of the later results in the cases of Nélaton and Laugier, the advisability of nerve suture in surgery was very problematical.

Guérin[2] was also opposed to the use of sutures, as, in his opinion, it was a dangerous auxiliary. He was familiar with healing by first intention, and held that the nerve ends must be approximated, when the exudation of plastic material between the ends was all that was necessary for a functional reunion by the ourth or fifth day; but he was opposed to securing this approximation by means of suture.

Eulenburg and Landois[3], in a further research, corroborated their former conclusions, and added the further objection to the

[1] *Berl. kl. Wochenschr.*, 1864, I., Nos. 46, 47.
[2] *Gaz. Méd. de Paris*, 19, 1864, p. 415.
[3] *Schmidt's Jahrbücher*, 1865, Bd. 128, S. 320.

use of the suture that it not only did not hasten, but actually hindered reunion. This conclusion they drew from an experiment in which they had sutured the sciatic with iron wire. The foot became gangrenous, but the wound and gangrene both healed. Function did not return, although the animal lived for several months. On examining the seat of suture, they found the nerves united by a mass of connective tissue without any trace of nerve fibres.

The unfortunate results obtained by Eulenburg and Landois, which led them to declare against nerve suture, were in a measure counterbalanced by the work of Magnien[1] published soon afterwards. From many cases of suture performed by him in horses, rabbits, and cats, he was led to conclude that the suture in no way does injury; and in two cats he found after suture return of sensation in seven and eleven days, and of motion in fifteen and twenty-five days respectively.

In the following year attention was drawn to a fact which seemed at the time inexplicable. The view that division of a nerve involved complete anaesthesia of the parts supposed anatomically to be exclusively supplied by that nerve was shown by Richet[2] to be not without its exceptions. A female who had received a wound above the annular ligament at the wrist was examined by him, and the median nerve was found divided. On cutting a portion from the distal segment great pain was produced, and, moreover, the region of the skin supplied by the median nerve still retained its sensibility; yet the muscles were paralysed. The nerve was sutured, but the operation does not seem to have been followed by return of function in the muscles. Lockhart Clarke,[3] who saw the case eight days after the injury, testifies that the sense of touch was perfect, that the part touched was rightly localised, but that the sense of pain was dulled, and temperature sense unsatisfactory.

A similar case was published immediately afterwards by Kiallmark.[4] The case was one in which the ulnar nerve had been divided at the elbow. A portion was cut off, producing thereby great pain, and this portion seemed to Kiallmark to include the whole thickness of the nerve. Yet, beyond slight

[1] *Virchow-Hirsch, Jahresbericht*, 1866, Bd. 1, S. 115.

[2] *Gaz. des Hôpitaux*, 1867, pp. 519, 531, 555.

[3] *Lancet*, 1867, vol. 2, p. 747.

[4] *Lancet*, 1867, vol. 2, p. 747.

numbness in the little and ring fingers, the patient complained of no impairment of sensation or motion in the hand or forearm, and in a few days resumed his occupation.

Richet attempted to explain his case on the theory of recurrent sensibility, and also thus explained the return of sensation in Laugier's case, and asks if the sensibility in that case was ever really absent. He also states that, contrary to the account of Nélaton's case, published by Houel, Nélaton had told him that the sensibility remained after section, and before the suture had been applied.[1] But the cases remained more or less enigmatical until the following year, when Arloing and Tripier[2] made a series of experiments on dogs with a view to explain the phenomena. For their purpose they found the fore limb of the dog most suitable. Their work was divided into two parts—first, the explanation of the sensibility remaining in the distal segment of a divided nerve; and, second, the explanation of the sensibility in the skin after division of the nerve which is supposed exclusively to supply it.

They found, on examining by the Wallerian method, that after section of a nerve some fibres remained in the peripheral segment which did not undergo degeneration; and to these was due the sensibility of the segment. They also found that, as long as one of the collateral nerves remained undivided, this sensibility was retained in a greater or a less degree, provided that the section was made below the elbow. With regard to the sensibility of the skin, they found that it was impossible to find a part of the skin which was exclusively supplied by a single nerve; that the section of one of the four collateral nerves supplying a toe produced no change in the sensibility; that the section of two produced scarcely any loss of sensibility; that the section of three produced a more marked loss; and that it required the section of all four to effect a total anaesthesia. They, therefore, concluded that the nerves supplying the paw formed by anastomosis a network in the skin, and that each papilla was supplied from all sources, and that some of the fibres of this network ascended the stems of the nerves, accounting for the undegenerated fibres seen microscopically, and for the recurrent sensibility. This explanation, then, was taken as accounting for the phenomena observed in cases such as that of Richet: the sensibility was there retained, owing to the neighbouring nerves also taking part in the supply of that part of

[1] *l.c.*, p. 555.

[2] *Compt. Rend. de l'Acad.*, tom. 67, 1868, p. 1058; tom. 68, 1869, p. 547.

the skin which was apparently exclusively supplied by the median nerve.

In the following year a case was observed by Létiévant,[1] which was unexplained by anything which was known at the time. The case was one in which, for the treatment of tetanus, arising from a wound in the hand, he had divided the median in the upper third of the arm. He found, on examining a few hours after the operation, that not only did the sense of touch remain in the median distribution, but although all the muscles supplied by the median were paralysed, there were present traces of movements resembling those performed by the paralysed muscles. After nine months, while the muscles supplied by the median were still paralysed, and now atrophied, the movements were strongly developed. Thus flexion of the index and middle fingers, and flexion, abduction, and opposition of the thumb, were all possible to a greater or less degree. On this case Létiévant founded his theory of the "*suppléances motrices et sensitives,*" a theory which has since been taken to explain return of function after nerve section in many cases in which that return was really due to regeneration, with imperfect return of function. His theory is that neighbouring muscles take the place of the muscles which are paralysed, though necessarily in an imperfect degree. Thus in his case, although the pronators were paralysed, still their function was imitated by the internal rotators of the humerus at the shoulder joint, coupled with the flexors of the forearm, the mechanical weight of the hand rendering the movement easier. The first phalanges were flexed by the interossei; the flexion of the second and terminal phalanges of the middle finger by the tendinous expansion which associates its flexion with that of the ring finger; while the second and terminal phalanges of the index and terminal of the thumb were passively flexed by the extensors of the metacarpus pulling on the paralysed flexor tendons; while the feeble opposition of the thumb was effected by the simultaneous contraction of the abductor and short flexor muscles. The retention of sensibility as far as touch is concerned he explained as due to the finer anastomoses, and also to the sense of touch mediately communicated to neighbouring normal papillæ.

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[1] *Virchow-Hirsch, Jahresbericht,* 1869, Bd. 2, SS. 291, 321. *Traité des sections nerveuses.* Paris, 1873.

But there have been several cases published in which, after section of a nerve, although anæsthesia resulted after the section, and although it was concluded that reunion of the nerve had not occurred, yet sensibility returned in the course of time. Weir Mitchell[1] published a case of this kind, in which for neuralgia he resected three-quarters of an inch from the median in the forearm, and doubled up the ends to prevent reunion. Examined two weeks later, "there were large regions of the hand into which a needle could be thrust deeply without causing pain." The following year he removed three inches from the musculo-spiral; and a portion of this nerve had three years before been resected, and regeneration had occurred. Some weeks after the second operation on the musculo-spiral, sensation returned in the median distribution, and there was also a notable retention of sensibility in the region supplied by the radial nerve. For this sensibility, according to Weir Mitchell, only some filaments of the internal cutaneous, of the musculo-cutaneous, and of the ulnar were responsible.

To account for such cases Tillmanns[2] suggests that from neighbouring intact nerves filaments can grow out into the anaesthetic region, and instances the experience which is met with in the plastic operation for repair of the nose from the tissue of the forehead, where for some time the patient refers the sensation of touch in the flap to the forehead, but ultimately rightly locates it. A more probable explanation of this phenomenon is that sensation is conducted along twigs passing into the flap, which at first the patient refers to the forehead, as he has been accustomed to, but that he ultimately learns by experience to refer the sensation to the new position.

The explanation given by Remak[3] to account for these cases with delay in return of sensation, and yet without reunion of the nerve, is that the anastomosing fibres may become developed, in a way comparable to the development of the collateral circulation after occlusion of an artery.

These theories, while they may be applicable, and doubtless are, to certain cases, have been made use of by some to account for early return of function after nerve section, when in many of the cases to which these explanations are given, the return of

[1] *The American Jour. of the Med. Sciences*, vol. 71, 1876, p. 321.

[2] *Archiv f. kl. Chirurg. v. Langenbeck*, 1882, Bd. 27, S. 1.

[3] *Berl. kl. Wochenschr.*, 1880, S. 126.

function is really due to nerve regeneration. Indeed, Tillmanns and others refuse to take the return of sensibility at all as evidence of functional reunion of a divided nerve, unless that also is accompanied by return of voluntary muscular power. The view which many hold of the process of regeneration involves for its accomplishment the lapse of a considerable period of time. Others, again, hold that, if the divided nerve is immediately sutured, it may heal by first intention, and function be restored speedily; but if this fails, the prolonged process of regeneration must occur. Yet there are many cases published in which the process of healing by first intention has manifestly failed, and in which the return of sensibility occurs too soon for the process of regeneration usually accepted to have occurred. For these cases the theories which have been described are taken as an explanation. Thus Vanlair,[1] who holds that, if first intention can occur, it is very exceptional, holds that, if sensibility returns very soon after nerve section, it is due to anastomosis, and the anæsthesia present for the short interval has been due to the numbing effects of hæmorrhage; if more slowly, it is due to supplementary fibres; and if there is a very long delay before restoration of function, then it is due to regeneration.

The histology of degeneration and regeneration of nerves has been so frequently investigated, that from the time of Waller scarcely a year has passed without the appearance of one or more papers upon the subject. Most of these investigations have been conducted on rabbits, fowls, guinea-pigs, dogs, cats, and rats. On some of the questions almost all are in agreement, while on others there is great diversity of opinion. All authors agree with Waller that the ultimate result of separation of a nerve from its centres is degeneration of the part separated; but, in opposition to the majority, who regard this degeneration as inevitable, Schiff, Bruch, Guérin, Hertz,[2] Gluck,[3] and Wolberg[4] believe that, if the divided ends are accurately coapted, and reunite before degeneration occurs, healing by first intention takes place, and the degenerative process is avoided. All are also agreed since the work of Schiff and that of Lent that, preceding the Wallerian degeneration, there is a traumatic degeneration affecting a small portion

[1] *Archives de Biol.*, 1882, tom. 3, p. 379.
[2] *Virchow's Archiv*, 1869, Bd. 46, S. 257.
[3] *Ibid.*, Bd. 72, 1878, S. 624.
[4] *Deut. Zeitschr. f. Chirurgie*, Bd. 18, 1883, SS. 293, 484; Bd. 19, S. 82.

of the central and peripheral ends. Much diversity of opinion, however, exists as to the nature of degeneration and the parts of the nerve fibre which it affects. The older writers, Nasse, Schiff, Landry, Walter,[1] and others, describe the change as simply a fatty degeneration, the resulting fat being simply absorbed. Bruch, again, regards it as a coagulation, comparable to that which takes place after death, but ultimately becoming fatty. Ranvier[2] regards it as caused by the increase of the nucleus and protoplasm of the internodal segment, which first cuts the contents of the fibre into two in the middle of the segment, and ultimately breaks them up into segments by the increase of the protoplasm lying in the indentations of Schmidt.[3] Meanwhile the medullary sheath breaks into an albuminous and fatty constituent, and is gradually absorbed under the influence of the increasing protoplasm. Howell and Huber[4] find that the process begins as a coagulation, and that the myeline breaks into the segments of Lantermann[5] before the increase of protoplasm commences. The further fragmentation and absorption is brought about under the influence of protoplasmic increase, but a fatty element is not found. Colasanti[6] and Tizzoni[7] regard it as, in the first instance, a breaking up into the segments of Lantermann; and the latter holds, along with Korybutt-Daszkiewicz,[8] that the further destruction takes place by means of leucocytes, which have wandered into the interior of the fibre by diapedesis, through openings in the sheath of Schwann, or at the cut end. Ranvier, it may be mentioned, describes the entrance of leucocytes into the fibres of the central and peripheral ends, under the influence of which the medullary sheath is broken up; but he holds this view only for the traumatic degeneration, and maintains that in the paralytic degeneration of the distal segment they take no part. Stroebe[9] holds that the contents of the tube break up into irregular masses, which are partly fatty, and that the corpuscles formed by pro-

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[1] *Virchow's Archiv*, Bd. 20, 1861, S. 426.
[2] *Compt. Rend. de l'Acad.*, 1872, p. 1831.
[3] *Monthly Microscop. Journ.*, 1874, vol. 11, p. 200.
[4] *Journ. of Physiology*, vol. 13, 1892, p. 335; vol. 14, 1893, p. 1.
[5] *Archiv f. mikros. Anat.*, Bd. 13, 1877, S. 1.
[6] *Archiv f. Anat. u. Physiol. (Physiol. Abth.)*, 1878, S. 206.
[7] *Centralblatt f. die med. Wissensch.*, 1878, No. 13, S. 225.
[8] *Virchow-Hirsch, Jahresbericht*, 1878, Bd. 1, S. 47.
[9] *Ziegler's Beiträge*, 1893, Bd. 13, S. 160.

liferation of the nuclei of the sheath of Schwann and the protoplasm act towards the degenerated contents as phagocytes, transporting them into the lymphatic system. Büngner[1] and Notthafft[2] regard the shrinkage of the axis-cylinder as the cause of the first fragmentation of the contents of the tube, and the increase of the internodal protoplasm and nuclei as the cause of the further breaking up and absorption.

Neumann,[3] Eichhorst,[4] and Dobbert take a different view from that of any other authors, namely, that the change after section is not a true degeneration, but a chemical alteration both of the myeline and of the axis-cylinder, whereby the difference between these two disappears, and the sheath of Schwann is filled with homogeneous protoplasmic contents, nothing being absorbed. This view they take from the different reaction to osmic acid of the contents of the tubes at various stages of degeneration. They find, as others have found, that the bluish-black stain characteristic of myeline gradually changes and becomes less intense, until the colour is a uniform greenish yellow, and this they take as indicating not a replacement, but a gradual change of the contents to protoplasm. They also think that their theory is favoured by the fact that the sheaths of Schwann at the ultimate stage of change are in transverse section circular, and not collapsed as they would be if empty.

Opinions are divided on the parts of the nerve fibre which degenerate. The view taken by Waller that the whole of the fibre degenerates, namely, that the axis-cylinder and medullary sheath are broken up and absorbed, and that the sheath of Schwann becomes simply a string of connective tissue, is supported by Walter, Landry, Ambrosoli, Eulenburg and Landois, and Vanlair; also Benecke,[5] Bertolet,[6] Bakowiecki,[7] Ranvier,[8] and recently Büngner, Howell and Huber, Stroebe, and Notthafft hold to the same view, but modified in so far that, while the axis-cylinder and

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[1] *Ibid.*, 1891, Bd. 10, S. 321.

[2] *Zeitschr. f. wissensch. Zool.*, Bd. 55, 1893, S. 134.

[3] *Archiv der Heilkunde*, IX., 1868, S. 193. *Archiv f. mikros, Anat.*, Bd. 18, 1880, S. 302.

[4] *Virchow's Archiv*, 1874, Bd. 59, S. 1.

[5] *Virchow's Archiv*, Bd. 55, 1872, S. 496.

[6] *The American Jour. of Med. Sc.*, vol. 71, 1876, p. 321.

[7] *Archiv f. mikros. Anat.*, Bd. 13, 1877, S. 420.

[8] *Leçons sur l'histologie du système nerveux.* Paris, 1878.

medullary sheath are early destroyed and absorbed, the sheath of Schwann remains until it is disposed of to make room for the growth of the young regenerated fibres. The view maintained by Lent, Rindfleisch, Colasanti, Aufrecht,[1] Tizzoni, Leegaard,[2] Falkenheim,[3] and Peyrani[4] is that the axis-cylinder and the medullary sheath are destroyed and removed, and that the sheath of Schwann persists. Hertz takes the same view, except for the cases where healing by first intention occurs; and Erb[5] that in slight injuries, such as compression, the axis-cylinder is retained; but that where there is complete division it is destroyed, but only at a late period, and that even then it may be of importance for regeneration. Vulpian, also, in his later work, finds that the axis-cylinder disappears. Ranvier holds that, in the traumatic degeneration of the central end, the axis-cylinder is only exceptionally destroyed.

That the medullary sheath is destroyed, while the axis-cylinder and sheath of Schwann are retained, is the view advanced by Schiff, Philipeaux and Vulpian, Hjelt,[6] Magnien, Laveran,[7] Hertz (for cases where first intention occurs), Erb (for slight injuries), Gluck, Mitchell,[8] Wolberg, while Korybutt-Daszkiewicz holds that the axis-cylinder is broken up, but retained; and Remak believes also that it is retained, not from direct observation, but on the ground that he found that it belongs to the most resisting structures of the body, resisting putrefaction longer than bone.

The increase in the number of the nuclei of the sheath of Schwann during the process of degeneration has been observed by all, but the phenomenon has been differently interpreted. Schiff, Lent, and Wolberg state that the increase in number is only apparent, that it is not due to multiplication, but to the removal of the myeline, which previously hid the nuclei now visible. With these exceptions, the authors generally believe that the increase in numbers is real, and most believe that it is due to proliferation from the pre-existing nucleus of the internodal

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[1] *Deutsch. Archiv f. kl. Med.*, 1878, Bd. 22, S. 33.

[2] *Ibid.*, 1880, Bd. 26, S. 459.

[3] *Deutsch. Zeitsch. f. Chirurgie*, Bd. 16, 1882, S. 31.

[4] *Virchow-Hirsch, Jahresbericht*, 1883, Bd. 1, S. 285.

[5] *Handbuch d. spec. Path. u. Therap. v. Ziemssen.* Leipzig, Bd. 12, S. 373.

[6] *Virchow's Archiv*, Bd. 19, 1860, S. 352.

[7] *Journ. de l'Anat. et de la Physiol.*, 1868, p. 305.

[8] *Injuries of Nerves.* London, 1872.

segment. There is, however, difference of opinion on the import of this proliferation. Eichhorst gives as his opinion that the nuclei have nothing to do with regeneration, without giving an opinion on their destination. Ranvier and others think that the multiplication of the nuclei and protoplasm is the active agent in bringing about the destruction of the medullary sheath and axis-cylinder by compression; Stroebe, that they act in part as phagocytes to the myeline and axis-cylinder. Howell and Huber, Stroebe, and Notthafft think that they take a subsidiary part in regeneration, while Hertz, Benecke, Bertolet, Aufrecht, Leegaard, Bowlby,[1] and Büngner take them as of the first importance in the regenerative process.

Friedländer and Krause,[2] in 1886, recorded their dissent to the generally accepted view that the central segment, with the exception of a very small portion at the cut surface, remains normal after section of a nerve. While admitting the degeneration of the peripheral segment, they hold that the central segment does not remain free from change. They made their observations in the nerves of the stump after amputation, and found that the transverse sections of such nerves do not present a normal aspect, but show a special form of degeneration, which they prefer to call atrophy. They found that about one-half of the nerve fibres are without myeline, and present in transverse section a point in their centre, which may be the axis-cylinder, but which they think is doubtful. These atrophic fibres are only about one-third the diameter of normal fibres. They then found that the anterior roots were normal, while the posterior contained principally fibres of this atrophic character. They hold, then, that in the central segment after division, the sensory fibres undergo this form of degeneration, while the motor remain normal. But all the sensory fibres do not so atrophy, and they give the hypothesis that it is only those ending in the tactile corpuscles of Wagner and Meissner and in the end bulbs which atrophy, while the fibres with free endings remain normal. In estimating the value of their work, it is well to remember that, with the exception of one case, which was three months after the amputation, and in which the atrophy was not so distinct, all the nerves which they

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[1] *Injuries and Diseases of Nerves and their Surgical Treatment.* London, 1889.

[2] *Fortschritte der Med.*, Bd. 4, 1886, No. 23, S. 749.

examined were from stumps of long standing, namely, from three to ten years.

Krause,[1] in the following year, published further investigations on the same subject. He examined human nerves from limbs which had been amputated for gangrene. The gangrene he takes as equivalent to section of the nerve, and the portion of nerve above the gangrene as equivalent to the central segment. He found, then, that on examining such nerves three to four weeks after the onset of the gangrene, about one-half of the fibres were in a state of degeneration not to be distinguished from the degeneration of the peripheral segment after nerve section. Both the axis-cylinder and the medullary sheath were affected, and traces of myeline were left, and there was proliferation of the nuclei of the sheath of Schwann, and he found that it was a centripetal degeneration. He then examined the peripheral segment of divided nerves in the rabbit, and recognised the few sound fibres which many had seen before and regarded as recurrent fibres, and in the central segment he recognised a corresponding number of degenerated fibres. From this, seeing that one-half of the fibres degenerate in the central segment of the human nerve, he concludes that a similar number remain sound in the human peripheral segment, but he has not been able to verify this point. He puts forward the hypothesis that those fibres which degenerate in the central segment, and which, by analogy, he concludes remain normal in the peripheral segment, have their nutritive centres in the periphery, and these, he thinks, most likely situated in the touch corpuscles, which Wagner and Meissner showed to exist only in man and monkeys; and from the absence of these touch corpuscles he seeks to explain why, in the rabbit and other animals, so few fibres degenerate in the central segment, and remain normal in the peripheral. He concludes that in the central segment degenerate, and in the peripheral remain intact, all those sensory fibres which are in connection with a trophic centre in the periphery; and that in the central segment remain intact, and in the peripheral degenerate, all motor fibres, and the sensory fibres of the bones, periosteum, joints, muscles, tendons, fasciæ, and of the cutaneous nerves, those ending free in the skin. He explains on his theory how sensation may return after nerve section without return of motion, as this is caused by a centripetal

[1] *Archiv f. Anat. u. Physiol.* (*Physiol. Abth.*), 1887, S. 370.

growth of the peripheral segment, which forms attachments to other nerves.

This view of degeneration I have been led to oppose[1] from the examination of central and peripheral segments of nerves which have been divided or interrupted functionally by cicatricial bands. On examining transverse sections of such nerves, I found no evidence of degeneration in the central segment, nor of old undegenerated fibres in the peripheral segment. As the proportion of degenerated fibres in the central segment, and of sound fibres in the peripheral segment, as indicated by Krause, is considerable, there would have been no difficulty in recognising them had his view been correct. The fact that most of Krause's observations were made on nerves removed from limbs which had been amputated for diabetic or senile gangrene, may account for the appearances displayed in his sections, the degeneration being thus viewed as primary to the gangrene.

The period at which the degenerative changes begin is of great importance in the consideration of the possibility of reunion by first intention. While the traumatic degeneration of the cut ends occurs within a few hours, the paralytic degeneration does not show until the lapse of a longer period of time. This period has been variously given by different authors, and this discrepancy is explained by Ranvier, who shows that it is different for different species of animals. Thus he found that taking the physiological test of loss of conductivity to electrical stimuli in the rabbit, guinea-pig, and rat, conductivity was lost in forty-eight hours from the time of section, while it was retained in the dog, pigeon, and frog; in seventy-two hours it was lost in the pigeon and retained in the dog and frog; in four days it was lost in the dog and retained in the frog, and that it was retained in the frog for thirty days or longer. Also, the age and state of the animal caused variations. But these data refer to the stage in degeneration at which function is destroyed, the actual onset of degeneration being much earlier. Thus in the rabbit, according to Ranvier, the changes are in progress by twenty-four hours.

The authors who have published accounts of regeneration of nerves hold even more diverse opinions than are held concerning degeneration. The view which is held by the minority of original investigators, but which is the account most usually given in

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[1] *Phil. Trans.*, Series B, vol. 188 (1897), p. 257.

text-books, since the investigations of Ranvier, is that regeneration of the peripheral segment is effected entirely from the end of the central segment. According to Ranvier, the peripheral segment still contains the sheaths of Schwann after degeneration and absorption of their normal contents. Reunion occurs between the proximal and distal ends—at first, by means of granulation tissue. In the first days while degeneration is proceeding, the axis-cylinders of the central end swell up, and appear slightly bulbous, most of the axis-cylinders being retained in the region attacked by traumatic degeneration. These central axis-cylinders show longitudinal striation, which Ranvier takes as equivalent to the fibrils of Schultze, and from each old axis-cylinder sometimes one or two new axis-cylinders proceed, sometimes many, as if the old axis-cylinder had split into its primitive fibrils. These continue their growth as far as the old sheath of Schwann extends, that is, to the cut surface, and then pass into the cicatricial tissue. They pass across this, and some of the new axis-cylinders then pass into the interior of the old sheaths of Schwann of the peripheral segment, while others pass between them, and run in the endoneurial tissue. The new axis-cylinders continue to advance till they reach the end organs. Meanwhile the new axis-cylinder becomes clothed with its sheaths; and the new sheath of Schwann is distinguished, at first, by the shortness of its internodes. Often several new fibres are contained in one old sheath of Schwann, which is thereby greatly distended, and ultimately destroyed. At times the new fibre, after leaving the old axis-cylinder, divides, and the branches may again give off branches. Thus the peripheral segment acts merely as a guide to the developing new fibres, playing an entirely passive part in the work of regeneration. Ranvier is, therefore, at one with Waller, except that the former finds that the new fibres penetrate into the old sheaths of Schwann, as well as between them. Rindfleisch[1] gives the same account, with the difference that the old sheath of Schwann is retained for the new fibre. Vanlair believes that the new fibres never penetrate into the old sheaths of Schwann; and, moreover, he regards the peripheral segment as resisting the growth of the new fibres to the end organs, and even suggests the excision of the whole peripheral segment leaving the connective tissue sheath as a means of leaving the path clear for the passage

[1] *Lehrbuch der path. Gewebelehre,* 4 Aufl., S. 20. Leipzig, 1875.

of the new fibres, and hastening the progress of regeneration.[1] He finds that the new fibres at the time of their branching from the old are naked axis-cylinders; that they become clothed by a provisional sheath *(gaîne vitreuse)*, derived from the neighbouring connective tissue; that this becomes thinner as development proceeds, and between it and the axis-cylinder the medullary sheath and the new sheath of Schwann appears, while the provisional sheath becomes the fibrillar sheath. He finds also that maturation of the fibre occurs centripetally. In a later investigation Vanlair[2] has sought to discover the rate at which the growth of the new fibres occurs, and found that for the facial nerve it was at the rate of 0·3 mm. daily, and for the vagus and sciatic that of 1 mm. daily, both in the case of simple section with perfect coaptation. Reeently Howell and Huber have decided in favour of this process of regeneration, but their observations have led them to accord the peripheral segment a greater share in the work of regeneration. They find that the protoplasm and the nuclei of the sheath of Schwann in that portion of the nerve form spindle-cells, which unite so as to form protoplasmic threads running within the old sheath of Schwann. These they term "embryonic fibres," and find that, while they have no axis-cylinder, they possess a low degree of irritability and conductivity. These are formed even when the peripheral has no connection with the central segment; but they are not true nerve fibres. The latter are formed by axis-cylinders, which grow out from the axis-cylinders of the central segment, and insinuate themselves into the centres of the embryonic fibres. The latter develop the sheaths around the axis-cylinders. Stroebe also finds growth from the central segment as forming only the axis-cylinders, which penetrate either into the old sheaths of Schwann or between, and become clothed with new sheaths from the cellular elements of the peripheral segment; and Notthafft thinks that the new sheaths of Schwann are probably derived from the cells of the old.

The advocates of the view that the peripheral segment has an independent regeneration of nerve fibres differ in their views regarding the mode of origin of these fibres. Those who believe that the axis-cylinder is retained during degeneration point to that structure as the source of the new fibres. Thus Schiff,

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[1] *l.c.*, p. 485.

[2] *Archives de Physiol. Norm. et Path.*, tom. 6, 1894, p. 217.

Philipeaux and Vulpian, Hjelt, and Wolberg believe that regeneration in the peripheral segment is simply a reaccumulation of the myeline, and Laveran thinks that the myeline is secreted by the nuclei of the sheath of Schwann. Korybutt-Daszkiewicz regards the remains of the old axis-cylinder as the source of the new. Remak, who observed as many as ten to fifteen small fibres enclosed in one old sheath of Schwann, regards them as having originated from the old axis-cylinder by longitudinal splitting.

This, however, only refers to the peripheral segment, and these authors have to account for the formation of new nerve fibres in the cicatricial mass uniting the cut surfaces. Hjelt, Wolberg, and Hanken[1] derive the new fibres here from the nucleated corpuscles of the perineurium. Laveran supposes that the intercalary segment is bridged over by outgrowth of axis-cylinders from the central end, and these find their envelopes from organised leucocytes; while Gluck finds that the tissue between the ends is a specific granulation tissue, capable of conducting impulses and forming spindle cells, which unite end to end to form young fibres, which bridge over the gap.

Neumann and his pupils, Eichhorst and Dobbert, who describe degeneration as a chemical change in the contents of the fibre, find that regeneration is a reproduction of the chemical differentiation between the axis-cylinder and the medullary sheath, but in this reproduction more than one fibre may be produced in one old sheath of Schwann. A new sheath of Schwann is formed around each new fibre, and the old disappears or becomes part of the endoneurial tissue. Neumann holds that the new fibres thus formed bridge over the cicatricial interval by growth both from the central and peripheral ends, and Eichhorst, that this is effected only from the central end.

Those who believe that the axis-cylinder is destroyed in degeneration hold different opinions on the mode of origin of the young fibres. Hertz thinks that in some cases they are formed from the white blood corpuscles, which become spindle-shaped, and unite by processes. Bruns[2] derives them from the corpuscles of the connective tissue of the nerve; and Hochwart[3] from the connective tissue corpuscle, or from the nuclei of the old sheath of

[1] *Schmidt's Jahrbücher*, Bd. 216, S. 129.
[2] *Virchow's Archiv*, 1870, Bd. 50, S. 80.
[3] *Schmidt's Jahrbücher*, 1887, Bd. 215, S. 17; Bd. 216, S. 130.

Schwann, which nuclei he regards as originally derived from the connective tissue corpuscle. But the nuclei of the sheath of Schwann have been taken by the majority as the source of the regenerated fibre. At first, before the relationship between the nuclei and the protoplasm of the sheath was understood, the nuclei themselves were taken as the source, but more recently the principal *rôle* has been given to the protoplasm.

Hertz finds that the new fibres are sometimes formed from these nuclei, which are surrounded with protoplasm. They become spindles, unite end to end, and form fibres. The outer part differentiates a medullary sheath and sheath of Schwann, while the central part remains as the axis-cylinder; and during the process many of the nuclei disappear, and the remainder become the nuclei of the new sheath of Schwann. Benecke gives a similar account, and attributes to the nuclei the secretion of the medullary sheath, which appears around them while many of the nuclei disappear. Bertolet, Aufrecht, Leegaard, and, recently, Büngner have all advocated the same view, the latter having described the process in detail after an extended series of researches. Thus he traced the development of the young fibres lying within the old sheath of Schwann from fusions of spindles derived in this way. The young fibre shows longitudinal striation, the beginning of the axis-cylinder. The new medullary sheath is formed from the outer layer of the young fibre, and also partly by absorption of the remains of the old myeline. The old sheath of Schwann disappears, and he regards the new as derived from the endoneurial connective tissue. The nuclei of the new sheath of Schwann are the direct descendants of the nuclei of the old sheath of Schwann, and have clearly the value of neuroblasts. The cicatricial tract is bridged over by the extension of these neuroblasts into it.

Thus the different views on the process of regeneration may be grouped under two heads:—

1st. The new fibres of the peripheral segment are produced exclusively from the central end by centrifugal growth.

2nd. The new fibres originate in the peripheral segment, and become connected to those of the central end.

According to the first view, the process of regeneration requires for its accomplishment the lapse of a more or less long period of

between the operation and the return of sensation is such that the return of function must be regarded as the result of the reunion of the nerve. In these cases sensation remained absent until the operation of suture was performed, and it cannot be supposed that the supplementary nerve supply made its appearance by coincidence at the time of secondary suture. Indeed Vanlair regards such cases as inexplicable by the theory of regeneration which he supports.

It is just such cases, which are now sufficiently numerous, which, taken together, form a strong objection to the view of Ranvier. In the cases which I have published[1], the nerves were severed in the forearm from a few weeks to eighteen months before the cases came under observation. They then presented complete loss of voluntary motion and of sensation, and marked atrophic changes in the distribution of the divided nerves, and yet, after reunion of the nerves by suture, sensation commenced to return at the end of from two to five days, and in a very short time localisation was perfect. The return of voluntary motion took much longer, and, indeed, in some cases, was only very imperfectly restored, and the opinion is expressed that this delay in recovery of muscular power is due to the atrophic changes which occur so rapidly in muscle after severance of the nerve which supplies it. The recovery of the muscle only begins when conductivity of the nerve is restored, and, with the muscles so far advanced in atrophy, it is not surprising that restitution should be a slow process. And, of course, if the nerve has been severed long enough to allow of complete degeneration of the muscle, then the return of voluntary motion by recovery of the affected muscles is impossible. To view the restoration of sensation in so short a period of time as from two to five days, as being due to a down-growth of axis-cylinders, as described by Ranvier, would require an altogether unnatural view of rapidity of growth to be adopted, and thus, merely on the clinical ground of early return of sensation, there is a strong objection to his view of regeneration.

But the microscopical appearances of portions of the central and peripheral segments still further oppose the view of Ranvier, and, at the same time, give an explanation of the early restoration of conductivity; for in the distal segment there are present abundant young nerve fibres. It has been shown that this was

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[1] *l.c.*

CRUIKSHANK'S PREPARATION (1776).
REUNITED PNEUMOGASTRIC NERVES OF DOG.
(HUNTERIAN MUSEUM, GLASGOW.)

first described by Philipeaux and Vulpian, and that Ranvier explained their observations by supposing that these authors had failed to observe strands of tissue connecting the two ends, and that it was through these that the young fibres had been communicated to the peripheral segment. In my cases, therefore, a careful search was made for such means of transit, and no communication of fibres between the two ends was found.

These young nerve fibres originate within the old sheaths of Schwann, and in the portions of the old nerve they are seen, to the number of four to eight, lying within the sheath. But at the cut ends of the nerve, where they are lying in newly-formed connective tissue, they are present in bundles containing as many as twenty or thirty, and without any definite sheath. In the central end of the nerve, examined by longitudinal sections, the old fibre is seen terminating abruptly, and the continuation of the old sheath of Schwann is occupied by a bundle of young nerve fibres, and it is evident that these might be taken for branches from the end of the old axis-cylinder. But transverse sections near the termination of the old fibres exhibit appearances which account for the origin of the young fibres in a different way. In these the young fibres are shown lying between the sheath of Schwann and the medullary sheath in the position of the protoplasm. They are not formed from the nuclei, as these are still visible, and it is clear that the formation of spindle-cells from the protoplasm of the sheath, as described by Büngner, will explain the appearances presented in such sections.

On these grounds, the view which I hold is that the young nerve fibres are produced by the fusion, end to end, of spindle-cells produced by proliferation of the cellular elements of the sheath of Schwann, that the axis-cylinder is a specialised strand of protoplasm, while the nuclei of the cells remain attached to the sides of the young fibres, and remain as the nuclei of the internodes.

With the formation of young nerve fibres in the peripheral segment in this way, while it is still separated from the central segment, the early return of sensation is explained, as it is only necessary that, on suture, union should occur between the ends of the young fibres of the two segments of the nerve to allow of the re-establishment of conductivity.

IX. — *Faradimeter, for measuring Alternating Currents for Therapeutic Use, designed by* SAMUEL SLOAN, M.D., Glasgow.

[Read before the Society, 9th February, 1898.]

I THANK you for the opportunity you are affording me of showing my Faradimeter to the members of the Philosophical Society of Glasgow, which I am doing at the kind request of Professor M'Kendrick and by the permission of your Council.

Since the introduction of the milli-ampère galvanometer into electro-therapeutic practice, electricity has been much more employed as a therapeutic agent and has given much more satisfactory results. But this instrument is quite useless as a means of indicating even the presence of alternating currents, such as the faradic and the sinusoidal. Without the means, however, of measuring these currents, or the assurance that the patient, in mild applications of them, is really receiving any current at all, progress in their use must be slow; and their employment must continue to be more or less empirical, depending largely on the sensations of the patient and the enthusiasm or impatience of the medical man for their acceptance or rejection, as therapeutic agents.

It was impressed upon me a year or two ago, after having been working for some years, so far in the dark, with these currents, that any reliable instrument for indicating the presence of currents as small as electro-therapeutists use, and, if possible, for reaching some measure of accuracy in registering the amount of current used, would add greatly to the employment of these currents, and render their mode of action better understood. Having seen no reference to such an instrument in any work on electro-therapeutics, and being unable, after enquiries, to obtain anything at all approaching what I desired—the ordinary electro-dynamometer, as Siemens', not being constructed for such a purpose—I set myself to design one.

I am pleased to say that, after many failures and disappointments, I have at last succeeded in devising an instrument which

has completely met the object I had in view, and has acted as a stimulus to me in the use of these currents; and I have now the pleasure of submitting a description of my faradimeter to you for your consideration and criticism.

What impressed me, perhaps, as the principal reason for the employment of such an instrument was my experience of the use of small currents, especially in the case of nervous patients, where I had to trust entirely to the sensations of the patients, especially after the first few minutes of the application, when the current becomes less felt. Here the constant mental strain induced in the patient by my repeated questionings as to whether there was any current at all felt, to a great extent deprived the treatment of much, if not of the whole, of its value, and frequently made me feel very foolish when, on proceeding to disconnect the wires, I discovered that they were already disconnected; and, so far as I or my patient knew, had been so for a considerable part of the *séance*—so uncertain is the patient frequently as to whether the current is on or off. My faradimeter then, to serve the purpose I had in view, must be able to indicate a current so fine that it might be passed through any part of the body of the patient without being felt. This can, of course, be done in the case of the galvanic current by means of the ordinary clinical galvanometer. But this instrument is, as I have said, quite useless when employed with any alternating current; for the needle either remains at zero whilst the current is passing through the galvanometer, or else the needle diverges to one or other side according to the direction of the initial current; remaining there though the current in each direction may be of the same force. Early in my work I found that currents as high as the patient could bear internally (10 to 20 milli-ampères) would show some deflection of the needle in my rude instrument; but I discovered later on that a great deal of patient work was before me if I wished the instrument to be so sensitive as I have indicated it was my object to make it. I accordingly set myself again to find if such an instrument could be obtained ready to my hand. I applied to all the principal instrument makers in Scotland and England, and also communicated with continental makers; but I found that, with two exceptions, I could get no help. In one of these cases I was promised by-and-bye an instrument capable of measuring very small intensities, but as it was to be on the principle of Lord Kelvin's electrostatic voltmeter, it could not serve

my purpose, since no current would be passing through it when in action. In the other case I was offered what seemed exactly the instrument I desired; but, as it was apparently only in an embryonic state like my own, I determined to design one for myself.

Other workers in this field besides myself have realised the need for such an instrument. From communications I have had with some of them I find that they consider the attempt impracticable, though they admit that an instrument capable of measuring the faradic current would be "most useful and much appreciated." Some of the appliances which have been recommended for this purpose are of use only for determining what current *ought* to be passing through the patient as compared with what ought to be present under certain altered circumstances. Thus a current of definite value may be proved to be present in the patient when, owing to some accidental break in the connections, no current is present at all, the proof of the presence of the current being still the sensations of the patient. In Bigelow's "International System of Electro-therapeutics," page A-122, published in 1894, I find the following with reference to this subject:—"A faradimeter was recently promised by an able and enthusiastic American author whose efforts have so far, it would seem, not been successful."

The principle of action of the instrument which I am venturing to call a faradimeter is the rotation of a coil, when suspended between the ends of two fixed coils, by electro-magnetic attraction and repulsion. These coils are arranged in series. I was at first told by electricians that my principle was bad, the currents I was dealing with being too small. I was afterwards told by others that the instrument I was aiming at had been already made and could be obtained from Messrs. Elliott Brothers, of London. To this firm I twice applied for such an instrument only to be told, in answer to my first communication, that they could not supply me with it; and, in response to my second application, that no such instrument was at present in the market.

There are four coils in all in this instrument, three in front and one compound one behind for the shunts, the last wound non-inductively. Of the three coils, two are large and are fixed, whilst the third, which is small, is suspended between the extremities of the fixed coils as I have mentioned. Of course, the ends of the coils between which the suspended coil lies are always opposed to each other in action, one attracting what the other repels, no matter what the direction of the current. An aluminium needle is

attached to the suspended coil so that the amount of rotation can be read off on the scale in front.

The fixed coils contain each between 3,000 and 4,000 turns of No. 32 wire. The suspended coil is relatively small and light. It is wound with about 1,700 turns of No. 46 wire. It is spindle-shaped, being one inch long, half an inch in diameter at the ends, and nearly three-quarters of an inch in diameter in the middle. The space in which it has to rotate between the fixed coils is three-quarters of an inch. This coil, with connecting rod and small bar magnet—the use of which I shall afterwards explain—needle, dipping wire, and rod, to balance the needle posteriorly and carry off the current, weighs about 180 grains. It is suspended by a very fine ribbon of phosphor bronze, about 10 inches in length, from the junction of two large brass uprights, where, by means of milled-head screws, it can be turned, raised, or lowered, as may be required. This metallic thread carries the current to the suspended coil. A similar metallic thread, but left perfectly loose, conveys the current from the coil by means of the posterior arm to the junction of two smaller brass uprights, and thence to the other terminal. The ends of this ribbon are held tight by means of screws. I have tried many measures for carrying off the current from the suspended coil, but they were all more or less faulty. This arrangement, however, has given me perfect satisfaction. The current thus passes from one terminal through the first fixed coil, then through the other, from it to the large brass upright, thence by means of the bronze ribbon to the small coil, and from it by the arrangement I have described to the other terminal. The first means I tried was the usual mercury cup, but the suspended weight was too light to bring the dipping wire back to the same point in the mercury, if it became displaced by the indicating needle being driven with force against the restraining pins, as by a strong current suddenly put on. Thus, the needle was prevented, in such circumstances, from coming back exactly to zero, unless after considerable tapping of the brass upright, which necessitated previous removal of the glass cover which is necessary to protect the instrument from currents of air. The dipping wire is still there, but it now dips into a cup of oil which prevents swaying of the coil and consequent unsteadiness of the needle. A fine wire also passes from the needle, about its middle, into a trough of superfine watch oil, which the fine point of the rigid wire is just permitted to touch. This prevents oscillation

of the needle when the current is broken and enables it to come back to zero in a few seconds. The instrument is held down by two strong clamps for steadiness when working the current reverser.

The faradimeter is now very reliable, very sensitive, and, as I have indicated, almost dead beat. The current reverser I have referred to alters the direction of the currents in the suspended coil, so that there may be readings on either side of the zero line —the left side of the scale being for lower readings, and the right side for higher currents. There are three shunts, so as to increase the range of the instrument.

The rotating coil has a resistance of about 355 ohms, and the two fixed coils have between them about 135 ohms resistance. The shunts, when in use, permitting only a fraction of the current to pass, the rest of the current goes by a more easy path, and thus comparatively low voltage currents may pass in sufficient quantity. Obviously the removal of so much resistance from the circuit owing to this double circuit in the instrument, when one of the shunts is closed, sometimes considerably increases the amount of current which the patient is receiving. The external resistance has, therefore, sometimes to be increased before closing the shunt.

I have mentioned that there is little torsion power in the suspending metallic ribbon. The controlling power which the suspended coil has to overcome, when under the influence of the current, is, however, obtained by means of two permanent magnets fixed on to the large brass uprights. These act on a small bar permanent magnet fixed at the upper end of the rod which connects the ribbon with the suspended coil, and which is also firmly fixed to the latter. The closer these magnets are—for they are movable—to the cross bar magnet the greater will be the certainty of bringing the needle back to zero; whilst the further apart they are, or the more they are raised above the level of the cross bar magnet, the smaller a current will the coil respond to. I have preferred to have them close enough and low enough to ensure an exact and ready return of the needle point to the zero line, though this renders the instrument unable to detect currents as small as it could if less accuracy were desired. I have been trying of late to dispense with the permanent magnets, but, so far, the results are not quite so satisfactory as with the permanent magnets. With the exception of these, *there is no iron or steel in the construction of the instrument.* As a convenience I have had

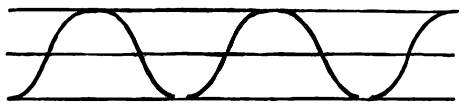
passed through an air-tight opening in the top of the glass cover a brass rod to set the needle at zero, if the magnets have not done so exactly, as, owing to currents of air, its relation to zero is not easy to ascertain when the glass cover is off.

This faradimeter is meant to be stationary; but, beyond being bulky, it can easily be carried about by simply tilting it to one side so as to enable the rotating coil to rest against either of the fixed bobbins during transit. When placed in its new position, the levelling of the instrument and the fixing of the wires to the terminals need occupy only a minute or two. The range of the registered readings is from 1 mill. amp. to 40 mill. amp. However, a movement of the needle can be detected with currents much smaller than 1 mill. amp. without tapping the instrument in the slightest degree. I find from experience that a minimum of $\frac{1}{4}$th of a mill. amp. and a maximum of about 20 mill. amp.—higher if alternating sinusoidal—include all that can be required for medical purposes. The former is less than the head can detect the presence of, and the latter is the highest which certain cavities of the body can tolerate—the minimum felt by the patient being generally about half of the maximum borne. Even this maximum can be tolerated only when currents of great intensity are passed, as from my largest coil, which contains about 8,000 turns of fine wire. The fewer the turns of wire are on the secondary coil the smaller is the maximum borne. The current of intensity is, therefore, the current of quantity also, and the slower the vibrations the less is the amount of current which the patient can bear. If it is desired to measure smaller currents than $\frac{1}{4}$th of a mill. amp., this should be done by increasing the windings of the fixed bobbins. The suspended one is probably as heavy as it should be.

I come now to the question of calibration. At first I graduated the scale by means of a galvanometer, using the constant current from a battery; reckoning that this was the nearest I could get to accuracy; since on using the commutator of my sinusoidal apparatus for converting the alternating into the galvanic—both being from the same coil—I found little difference in the position of the needle on the scale. Usually the galvanic was slightly greater than the alternating, but this was not invariably so. I found, however, to my surprise, when using the sinusoidal galvanic current, passing it through the galvanometer, instead of the battery current, to calibrate with, that one mill. amp. on the

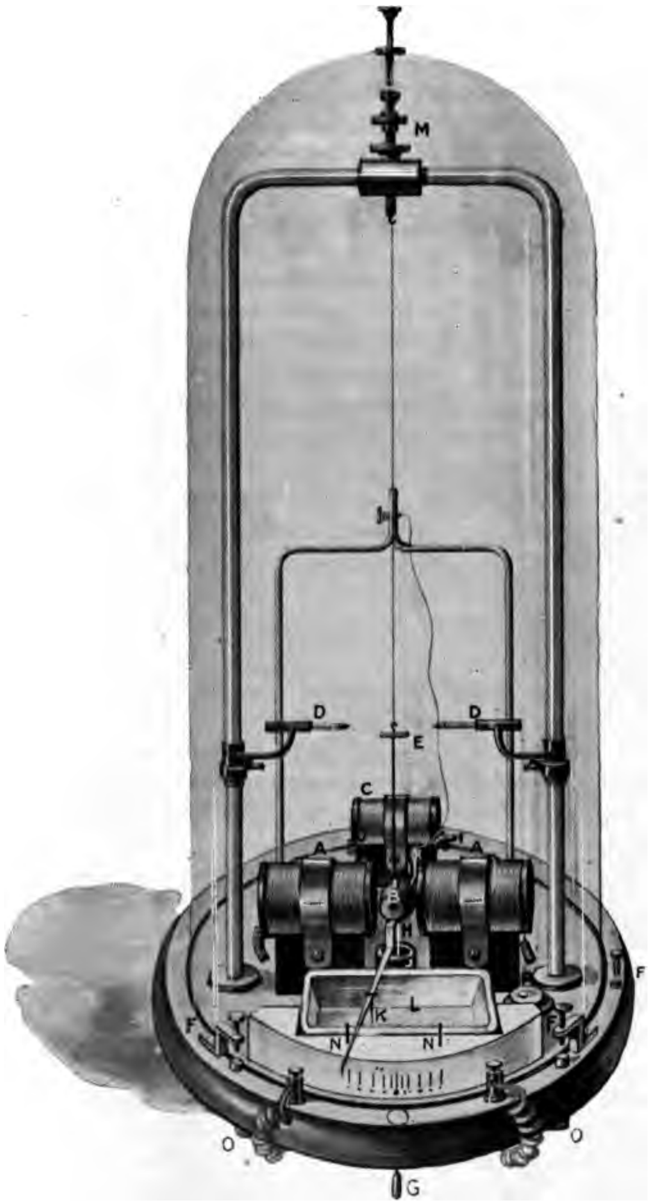
galvanometer became nearly what had previously been marked as two mill. amp. on my scale. Two mill. amp. became nearly four, and so on—always nearly double. I could only conclude that, whilst the galvanometric measurement was the average of this wavy current, my faradimeter gave me the distance of the *tops* of the waves from the zero line, thus :

Faradimetric measurement.
Galvanometric measurement.
Zero line.



Obviously, since the alternating sinusoidal gave practically the same amount of deflection at the same speed, and with the same resistance, the same reason holds good for the alternating as for the galvanic sinusoidal—namely, that the deflection of the needle was twice as much as the average of the current would have led one to expect. I have accordingly calibrated my instrument as if for the sinusoidal galvanic current; but lest the permanent magnets should alter their position or lose some of their magnetism in time, I have indicated by a dot on the scale the position the needle should occupy for five mill. amp. from a battery as read off in the galvanometer. The scale may thus be checked when desired by means of an ordinary mill. amp. galvanometer and a few Léclanche cells, and the scale again made true by altering the position of the magnets. Two dots are really required, since the needle will occupy different positions according to the direction of the current; for, being a constant current, the needle will diverge more or less according as the current diminishes or intensifies the power of the magnets, these being slightly in the magnetic field whilst the current is passing. This, of course, does not hold when the faradic current is passing.

It may be said that no accuracy can be expected when measuring the faradic current, the character of the curves varying so much by any slight change in the action of the rheotome. This is true, however, in a small degree only, and is not sufficient to diminish the value of the measurements for therapeutic purposes; for, if the reading does not give the actual measurement, it does give the virtual amount, and the record is relatively, if not absolutely, correct. But it may be asked—"What do you mean by one mill. amp. of the faradic current?" I answer—*It is the* ELECTRO-MAGNETIC *equivalent of an amount of* SINUSOIDAL ALTERNATING CURRENT *the* GALVANOMETRIC MEASUREMENT *of whose* SINUSOIDAL



DR. SAMUEL SLOAN'S FARADIMETER (about ⅛th nat. size).

AA, fixed coils; B, rotating coil; C, shunt coil; DD, permanent fixed magnets; E, permanent bar magnet, rotating with suspended coil; F, shunts; G, current reverser; H, dipping wire from suspended coil; I, posterior arm from suspended coil to balance needle, and carry off current by means of loose bronze ribbon; J, oil cup; K, rod from needle dipping into oil trough; L, oil trough; M, milled head screws for adjusting suspended coil; N, restraining pins; O, levelling screws; P, circular spirit level.

GALVANIC EQUIVALENT *is one mill. amp.* The measurement of the faradic current may be impracticable; it may even be unscientific to speak of this current in terms of the milli-ampère; but the result of this attempt to measure it is to the electro-therapeutist of practical value; nay, more, I am safe in saying that, with the same kind of coil, the same rapidity of vibrations of the rheotome, and the same amount of deflection of the needle, the therapeutic effect will always be the same. I am not aware of any instrument which can do as much. It is a reliable means of registering the presence of the current in the patient; and, other things being equal, it is an absolute register of the amount of current passing through the patient.

The instrument must be carefully levelled by means of the levelling screws when it is set up; and currents of cold air around it should, if possible, be avoided, even with the glass cover on, to prevent internal currents, which would slightly displace the needle, temporarily, from the zero line.

I have not yet had sufficient time to experiment much with this faradimeter, but it has opened up to me a field of enquiry which is very fascinating, and it has greatly increased my confidence in the therapeutic value of the faradic current and the alternating sinusoidal.

[The instrument has been made from my instructions by Messrs. Baird & Tatlock, of Glasgow and London.]

X.—*Note on a new Instrument (Oliver's) for the Estimation of the Colouring-matter of Blood.* By DAVID FRASER HARRIS M.D., C.M., B.Sc. (Lond.), F.R.S.E., Muirhead Demonstrator of Physiology in the University of Glasgow.

[Read before the Society, 9th March, 1898.]

THE first notice of this instrument was in the *Journal of Physiology*, 14th March, 1896 (Vol. XIX.), and thereafter in the *Lancet*, 20th June, 1896, where a full description of it appeared as a report of Dr. Oliver's "Croonian Lecture" that summer.

The principle employed—the only one practically applicable clinically—for estimating the percentage of oxyhæmoglobin is *colorimetric;* in other words, that of matching the exact tint of a known quantity of diluted blood by the tint of some one of a set of "standard" coloured glasses. [Malassez', Von Fleischl's, and Gower's instruments are also colorimetric.]

Oliver has designed a series of standard tints in glass (so stained that the pigmentary material is perfectly non-fugitive) which represent accurately, colorimetrically, the progressive dilution of human blood.

The actual tint of the diluted blood was, for each degree of the scale chosen, matched colorimetrically by skilled workers in Lovibond's colour-matching laboratories at Salisbury, by means of their coloured-glass standards.

The precise tint of standard glass for each of the dilutions of blood chosen was then rendered permanent by superposing two coloured glasses (orange and red), cemented on their edges, and covered by a colourless dust-proof glass screen.

These permanent tints were "standardised" by estimating chemically the percentage of hæmoglobin present in each of the specimens of diluted blood which they respectively matched.

The scale reads 10, 20, 30, &c., up to 120, these being per cents of the normal quantity of hæmoglobin present in human blood, which Oliver takes to be 15·5 per cent. of blood by weight. There are tinted glasses for reading to percentages between the fixed tints of the scale.

The specimen of blood drawn (5 cmm.) is mixed with water in a mixing cell of such capacity that when full it holds about 495

cmm. of added water—enough to ensure the complete liberation of all the pigment from the red blood-corpuscles.

Thus, if normal blood is being dealt with, its tint would be matched by the standard disc marked 100, which corresponds to 15·5 per cent. of hæmoglobin, ∴ 1 scale-degree is = ·155 per cent. of HbO_2. (Suppose that you match a given specimen of blood by the disc marked 70, that blood has $\frac{70}{100}$ of 15·5 per cent. or 10·85 per cent. of HbO_2.)

SPECIAL FEATURES OF THE HÆMOGLOBINOMETER.

1. The illuminating light is reflected (or doubly transmitted) from the bottom of a *dead-white* shallow cell which holds the blood. This is porcelain of the whiteness of compressed powdered calcic sulphate. Thus there is fixed even a standard of whiteness of background. The variable nature of the background is a great objection in Gower's instrument, while Malassez' has ground glass which is not white.
2. The pipette fills itself very rapidly by capillarity, and thus no measuring needs to be done. The diluting water is not actually measured either, it is rapidly squeezed out of the washing-out pipette until the mixing cell is so full that the liquid has a marked convexity, then, on the cover being lowered, the slight excess will overflow into the little ditch which surrounds the cell, and the cell itself will be quite full.
3. The receiving pipette is very stout, and can be cleaned out by a needle and thread; the washing-out pipette has an india-rubber nozzle, which fits easily over the end of the former, and thus the blood is able to be rapidly washed out before it can coagulate.
4. There is a standard illuminant (a "Christmas" candle), and the discs are viewed in the dark, below two holes bored in the bottom of long blackened tube otherwise closed.

The advantage of the dark is that all pigments show most satisfactorily when brilliantly lighted without shadows or cross lights, and that is obtained best in the dark. Further, a standard degree of illumination is necessary for two reasons—

1. The particular tint of a pigment is liable to differ, according to the *intensity* of the incident illumination, *e.g*, a red

card will appear a dull red in a dim or feeble light, but a bright red in a strong light. This very familiar fact comes to be of considerable importance when one assigns *values* to shades of difference in the depth of colour matched.

2. But, further, the particular tint or "purity" of a pigment varies even more according to the character (whether pure white or coloured) of the illuminating light.

Thus a "yellow" ribbon is *not yellow* in the *red* light of the spectrum, and a colour which is of one tint in daylight may become of another in gaslight, owing to the change in the precise chromatic constitution of the latter illuminant.

Since, then, the colour of solutions of oxyhæmoglobin will vary in intensity and purity, according to the intensity and purity of the illuminating light, we must, for *quantitative* colorimetric purposes, have a light of some definite (unavoidably conventional, arbitrary) standard; in other words, a source always giving out light of the same strength and of the same chromatic composition.

Hence it is a matter of some moment whether the blood be matched in daylight or candlelight, for (1) they vary in intensity—candlelight according to the size of candle used, daylight from hour to hour during the daytime, even in clear weather, and in towns is often so feeble as to be useless; and (2) they do not possess the same amounts of the same chromatic constituents, candlelight being much "redder."

The "specific colour curve" for blood in daylight therefore differs much from that in candlelight.

The *specific colour curve* for oxyhæmoglobin is the plotting-out (along ordinates) of the various unit amounts of depth of tint of three different colours (glasses) [red, yellow, blue], the resultant colour of which, when the three glasses are looked at superposed, matches the tint of the blood at the various increasing degrees of the concentration of its HbO_2 as marked along the abscissa.

It is curious that no "yellow" needs to be used to match blood in candlelight, probably because blood quenches the yellow rays of candlelight.

(In Von Fleischl's and Malassez' instruments, which have *wedges* of coloured glass, you must match a uniformly tinted area (blood) by one made up of increments of slightly altering depth of tint as you look from one end of it to the other.)

XI.—*The Present State of Deaf Mute Education.* By W. H. ADDISON, Glasgow Institution for the Deaf and Dumb.

[Read before the Society, 20th April, 1898.]

A LITTLE over a hundred years ago, in the year 1792, the first public school for the education of the deaf and dumb, (unfortunately miscalled an asylum) was opened in Britain. At that time little attention was paid to the education of the common people, and the education of a deaf person was considered little short of a miracle. This school, still named the London Asylum for the Deaf and Dumb, was the only one in existence at the beginning of the century, though it was soon followed by the establishment, in 1810, at Edinburgh, of the Edinburgh Institution for the Deaf and Dumb. The close of the century witnesses a very different state of things. By Act of Parliament it has been made compulsory that every deaf child in Great Britain, between the ages of seven and sixteen, shall attend a special school, and provision is made both for education and maintenance out of the rates, or by a special grant awarded after examination by a Government Inspector.

The nineteenth century should, therefore, be looked upon by the deaf and dumb, of this country at least, as the era of their emancipation from the bondage of ignorance, and their admittance into the Canaan of light and knowledge.

To quote the words of one of the most facile writers who have given their talents to the furtherance of the cause of the deaf mute:—

"It is to this nineteenth century of the Christian era that is due the whole of what has been achieved for and attained by the deaf as a class. At the beginning of this century they had no intellectual status, one may almost say no intellectual existence; only a small school here, an infantine institution there, and the remainder of the class immured in their homes for safety, or

rambling about the streets or lanes at the mercy of every accident.

"Now behold the difference, and note the growth which that difference evidences. In this last decade of the century schools are to be found in every part of the United Kingdom, in every country in Christian Europe, in the vast and spreading territories of the United States, in our own most distant colonies and foreign possessions; and, to quote last, you (*i.e.*, the teachers) are working here at home, under Government sanction, directed by Imperial legislation, and no longer under the fitful, though in its results most noble, action of private bounty and public benevolence." *

To place before the members of the Philosophical Society a brief summary of what has been and is being done at the present time, and to give some indication as to the lines on which further progress may be expected, is the object of this paper. Unfortunately we have at present no official bureau which makes it a business to collect regularly the facts regarding the deaf, and anyone who wishes statistical information regarding them has to collect it for himself and at his own expense. Matters have improved somewhat lately, as the Government now issue (annually) a small Blue Book dealing with the schools under inspection in England, but the subject in Scotland receives only a casual notice in the General Blue Book, and Ireland is left out in the cold altogether. It has been proposed lately by the editor of the *Silent Messenger* to publish an annual tabular statement, giving full particulars about the pupils attending the different schools of the kingdom, somewhat after the manner which the American Annals of the Deaf has pursued for many years. The writer is of opinion, however, that something more official should be attempted, and that the work should be done under the auspices of the National Association of Teachers of the Deaf, or of the Government itself. It is of the utmost importance to a scientific study of the subject that accurate statistics and records of careful observation should be available from time to time.

In order to collect matter for this paper, a reply post card was sent to as many schools as possible, soliciting information on certain points which the writer, who had previously done some work in the same field, thought useful, and the returns have been collated, with the following results :—

* Dr. Buxton, Conference Proceedings, 1895, p. 7.

The number of schools and institutions from which returns have been obtained are—

England, - - - - -	36
Wales, - - - - -	4
Scotland, - - - - -	11
Ireland, - - - - -	4

In November, 1895, when a similar enquiry was made, the figures were—

England and Wales, - -	31
Scotland, - - - - -	10
Ireland, - - - - -	4

so that we have an increase of 9 schools in England and Wales, one in Scotland, and none in Ireland.

Of these schools—

In England, 16 are boarding institutions and 20 day schools.
In Scotland, 6 ,, ,, ,, ,, 5 ,, ,,
In Ireland, 4 ,, ,, ,, ,, 0 ,, ,,
In Wales, 1 is a boarding institution and 3 day schools.

It is to be noted, however, that some of the boarding institutions have a considerable number of day scholars.

The number of pupils attending school is as follows—

	Boys.	Girls.	Total.
England, - - -	1,635	1,233	2,868
Wales, - - -	48	57	105
Scotland, - - -	284	265	549
Ireland, - - -	259	247	506
Total for United Kingdom,	2,226	1,802	4,028

To this total must be added at least 50 who are being educated in private schools or at home.

In November, 1895, the totals were—

	Boys.	Girls.	Total.
England and Wales, -	1,510	1,120	2,630
Scotland, - - -	285	239	524
Ireland, - - -	283	264	547
Totals, - -	2,078	1,623	3,701

Hence in a little over two years we have a difference in the number of pupils attending school of—

	Boys.	Girls.	Totals.	
England and Wales,	+ 173	+ 170	+ 343	+ 13 °/₀
Scotland, - -	- 1	+ 1	0	0 ,,
Ireland, - -	- 24	- 17	- 41	- 7 ,,

Comparing these figures with those which were obtained in 1885, we find that the number of deaf pupils attending school has increased since that time in England and Wales by 47 per cent., and in Scotland by 27 per cent., whereas in Ireland the number has decreased 9 per cent.

With reference to the question of boarding institutions *versus* day schools, we get the following figures:—

	Day Scholars.	Boarders.
England, - -	997	1,871
Wales, - -	53	52
Scotland, - -	109	440
Ireland, - -	5	501
	1,164	2,864

The day classes have multiplied rapidly in England since the Compulsory Act, which compelled School Boards to provide education, came into force.

The reason for this is to be found in the fact that (1) it is cheaper to educate a small class of eight or ten in a room in a public school rather than pay the higher fee which maintenance in an institution entails; and (2) that there is a natural feeling amongst parents in preference of keeping their children near them at home. Whether it is better in the long run to educate the children thus is a moot point, which can only be determined by careful observation and study of the results achieved by the two classes of schools.

This can only be done by some impartial authority, such as the Education Department, if that body can be induced to act as arbiter in such a thorny question.

TEACHERS.

The number of teachers employed is as follows :—

	Men.	Women.	Deaf.	Total,
England, - - -	90	191	7	281
Wales, - - - -	3	7	2	10
Scotland, - - -	20	31	5	51
Ireland, - - - -	21	26	12	47
	134	255	26	389

This gives to each teacher a class of—

In England, -	10·2 pupils,	Average, 10·5 pupils.
In Wales, - -	10·5 „	
In Scotland, -	10·6 „	
In Ireland, - -	10·7 „	

This is fairly satisfactory so far as quantity is concerned. Whether the quality is right is a question which can hardly be decided here. It is noticeable, however, that the women teachers largely outnumber the men, and the disproportion seems to be growing larger from year to year. This tendency is not confined to this country alone, for the same subject is agitating the minds of our brethren in America. Thus, from an American paper just to hand, we cull the following:—"Time was when all teachers were men. Conditions gradually changed, until now a majority of instructors of the young, at least in our country, are ladies. The excellence of a teacher depends rather upon the character than the sex. Still we believe that our youth can be best fitted for their duties in life if their education is not received wholly from one sex or the other." With which opinion we cordially agree.

The next point to be noticed in our statistics is the proportion of boys to girls. This we find to be as follows :—

	Boys.	Girls.		
England, - - -	100	75·4		
Wales, - - -	100	118·7		
Scotland, - - -	100	93·3		
Ireland, - - -	100	95·3	100	83·3
Average, - -	100	95·6		

It has been said* that the proportion of males to females (deaf and dumb) is about six males to five females. The ratio of males is greatest in early life, but the females possess greater tenacity of life, and at 65 years of age they show equality as regards numbers.

The figures now obtained of the sexes of the children actually attending school do not altogether corroborate this view, and seem to point to some error in the census returns.

It has long been suspected by experts that the census returns are not always reliable, as parents, and even enumerators, often make absurd mistakes in classifying children as "Deaf," "Deaf and Dumb," &c.

Method or System.

As is well known, much controversy has been excited over the question of the method by which deaf children should be educated. Unfortunately no nomenclature has been adopted which commands universal assent. An attempt has here been made to get a rough classification of the methods adopted, with the following result:—

	Oral.	Manual.	Combined.
England, - - - -	2,304	454	112
Wales, - - - -	39	54	12
Scotland, - - - -	87	112	350
Ireland, - - - -	42	464	506
	2,472	1,084	980

This return seems to show that the oral method is the one which finds most favour generally. It is to be observed, however, that several schools have returned themselves as oral schools, when it is a matter of common knowledge that the pupils therein quite readily understand the finger alphabet, and use it at least out of school. These schools, in fact, would be classified as combined system schools by some teachers. Till an exact definition is given to the words used to denote the different methods, we fear little importance is to be attached to these figures, except so far as they show the tendency of opinion amongst the managers of the schools.

* "Deaf Mutism, Census Returns," p. 212.

Efficiency of the Education given.

The question has been raised lately as to whether the education which is now being given is of as thorough a character as it was 20 or 30 years ago.

In a recent issue of *Ephphatha*, a magazine published in the interest of the deaf, Mr. Wright, Headmaster of the Newcastle Institution, is reported to have said:—

"A much larger proportion (of the deaf) is being educated, but I do not find that the standard of general education has advanced. I admit that their school curriculum now includes more subjects than were taught 20 or 30 years ago, but we must confess to a weakness in their composition, and a meagreness in their general knowledge and attainments, that was not so apparent in former days.

"Some headmasters and teachers with whom I have discussed the subject attribute this decline to the time spent over articulation; others say that now-a-days too much time is devoted to Kindergarten and manual training during school hours."

It would be difficult to say how far this view is correct, for there exists no means, except the reminiscences of old teachers, of comparing the attainments of present-day pupils with those of the past. It is obviously unfair to compare the attainments of school children with those of adults who have been mixing with the world for many years, and who have improved themselves by reading and study. The only true way to get a comparison would be for some authority, say the Education Department, to collect evidence from year to year and store it for the use of future students.

One cause of the apparent inferiority of present-day results may be that, under the compulsory clauses of the Education Act, many children of low vitality and intellect are swept into the schools, who, in the olden days, never saw the inside of a school at all. It is to be expected that the children of parents who were anxious for their children to go to school would be more intellectual than the children of those who require compelling to send them.

Another reason, which applies equally to the schools for hearing children as to those for the deaf, may be that the congregation of people in large cities, under unhealthy conditions, is sapping the physique and the moral and intellectual stamina of the people.

This is a point which requires consideration at the hands of all who have the welfare of the nation at heart.

It has a special bearing on the question of institutions *versus* day schools. It is, in my opinion, better to send defective children to places where the air is pure, the feeding is well looked after, and physical culture can be carried on under good conditions, rather than keep them in the close neighbourhoods, where so many of their parents are compelled to earn their bread.

It is to be remembered also that the compulsory clause has altered the conditions under which teaching is carried on. During the seven years that the Act has been in force in Scotland, the institution in Glasgow has simply been overwhelmed with applications for the admittance of new pupils. This has necessitated many alterations to the building, and the Directors have expended not less than £9,000 during this short time in building improvements. It goes without saying that this means disarrangement of the routine and interruption of work. The same thing is taking place in England, as the tables above given, and the reports of extensive alterations of the older institutions, prove.

Again, the age of the pupils must be taken into consideration. Formerly it was the exception to get the children at an early age. The pupils would be 12, 13, and 14 years of age before coming to school, and would stay probably five years. Now they come at 7 (some younger) and leave at 16, and this difference in age necessitates a different manner of teaching.

Language, the principal study in all deaf and dumb schools, used to be taught by the old grammatical method in vogue for teaching Latin 50 years ago—a method which, given ability on the part of the pupil, made many brilliant scholars, in spite of the disrepute into which it has now fallen.

Such a method, however, is obviously unsuitable for children of tender age. Moreover, it is apparent to observing teachers that, while it is eminently desirable to get deaf children into training at an early age, yet, if this means that their time is to be shortened at the other end, and they are to leave school before attaining the age of 16 at least, then the advantage of the compulsory clause will be largely neutralised. I am sorry to say that there is a tendency manifested in certain quarters to withdraw the deaf children from school before their education is as complete as it should be. Let us hope that the good sense of the community

will eventually make this selfish action of parents and guardians impossible.

One of the great defects in the action of the Education Department in connection with this question of deaf mute education is that, so far, little or no provision has been made for the proper supply, training, and retaining of the staff of teachers. Believing, as I do, that the teacher is practically the school, I think that the greatest pains should be taken to secure good teachers. But this cannot be done in the present state of the labour market without paying adequate salaries, and, while much improvement has taken place in recent years, there is still great room for further improvement.

It may be interesting to state what has been done in other countries in this respect.

In a pamphlet entitled "International Reports of Schools for the Deaf," issued by the Volteau Bureau at Washington, U.S.A., it is stated :—

"Few Governments, so far, exact well-defined statutory qualifications which applicants must possess in order to secure an appointment as teacher in schools for the deaf.

"Prussia, as early as 1811, and more definitely in 1831, prescribed examinations which, from time to time, have been perfected, and now, not only candidates for teacherships, but also candidates for the position of principal and superintendent throughout the German Empire, are subjected to a searching examination by a Board of Specialists before their names can be entered upon the register for vacancies which may occur. A similar practice prevails in Sweden and other Scandinavian countries; England, France, and Austria offer opportunities to secure certificates of qualification, but mandatory laws apparently do not exist.

"In America, only recently statutory requirements have appeared in the laws enacted by the States of Wisconsin and Illinois, of which the latter, in its recent law relating to public day schools for the deaf, enacts that :—'No person shall be appointed to teach in any such school who shall not have first obtained a teacher's certificate as provided by law, and who shall not have received specific instructions in the teaching of the deaf for a term of not less than one year.'"

The British Government is moving tentatively in the same direction, for the new code for England this year contains a

clause whereby students in training colleges who show special aptitude may, on the application of the authorities of their college, and with the consent of the Department, be allowed to take the second year of their training, in whole or in part, in an institution for training teachers of the deaf approved by the Department for that purpose.

What is really wanted, however, is a regulation that *all* future teachers of the deaf shall be properly trained and certificated before being allowed to take charge of a class of children in a State-aided school, and, in the writer's opinion, one year is utterly inadequate for the purpose of such training.

Higher Education.

Now that the elementary education of the deaf has been put under Government inspection, and is no longer left to charity, a demand is arising amongst the adult deaf and dumb for secondary and higher education. This desire was voiced at a conference of deaf mutes held in London last summer, in an able paper which was read by Mr. A. M. Cuttell, himself deaf, who edits the paper called *Ephphatha*, to which reference has already been made. Some movement in this direction has already taken place. Several School Boards, including our own Glasgow Board, have employed a teacher to give lessons in various subjects under the evening continuation code, and many deaf mutes have taken advantage of the facilities thus afforded. A large number are also to be found as students in the schools of art which exist in nearly every large town. It is no easy matter, however, to get lads and lasses, who have been working hard at their trade for 9 or 10 hours a day, to turn out to hard study in the evening, especially as many have to traverse long distances to and from their homes to their work and to the school.

The more ambitious deaf mutes, moreover, desire something better than can be obtained in this way. As Mr. Cuttell says:—"There are in each school two or three exceptionally bright pupils whose education might with advantage be continued. They have, I think, as much right to such as they had to their primary education. As things at present are, the training of such children is left off at a point where it is most desirable it should be continued, and thus, because they have 'no deepness of earth,' their talents and prospects practically wither away into

mediocrity. If an advanced department could be attached to some existing institution for the reception and training of these exceptionally bright pupils, the nucleus of a college would be thus established. After all, it is the *mind* which does the work of the world—not merely technical training, and if we enlarge the minds of our deaf students, they will be sure to force their way in the world according to their several inclinations and capacities."

In support of this plea for some provision being made for these children of exceptional parts, the advocates of it point to the success of the Gallendet College at Washington, U.S.A., the only institution that we know of where an attempt is made to educate on college lines.

This college, we learn from a report lately sent us, has, since its incorporation, chiefly devoted itself to the establishment and development of an advanced department, a college in which the education of the deaf might be carried forward so as to include courses of study in the higher mathematics and sciences, general history and literature, sociology and philosophy, the ancient and modern languages, and such technological studies as the deaf might be found capable of pursuing with profit.

The Principal, Dr. E. M. Gallendet, says:—

"When it was proposed in 1864 to establish at Washington a college for deaf mutes, a school only slightly lower in grade than your (British) universities, many doubted the capability of the deaf to receive the training of such a school, still less to profit by it. More than a few questioned the propriety of spending money for an education which they were sure could be of no practical value, and there were those who did not hesitate to characterise the scheme as one which would lift the deaf 'out of their sphere' only to make them discontented and unhappy.

"Happily for the deaf of our (U.S.A.) country, no such illiberal views prevailed, and Congress, in 1864, was induced to begin a series of appropriations, which have continued until we have in Washington an institution with ample grounds and commodious buildings, a corps of skilled professors and instructors, and all the essential appliances for conducting the most intelligent deaf young men and young women in our country through a five 'years'' course of study, in which they can be well grounded in the ancient and modern languages, the higher mathematics, the natural sciences, general history and literature, philosophy and

sociology, with a choice of technical studies, such as practical chemistry, engineering, architecture, and certain applications of the arts to industry.

"The success of our undertaking has justified beyond all question the wisdom of those who devised and proposed it to Congress.

"Five hundred and eight young men and young women have received the training of the college, and have proved by their intellectual development that deafness presents no obstacle to a very high degree of mental culture."

It remains to add that the cost of maintaining the institution here referred to, for the year ending 30th June, 1897, was 70,863 dollars—of which amount the large sum of 39,375 dollars was paid in salaries and wages. The number of pupils and students combined was 184. The whole cost was paid by a subvention direct from the State treasury.

If this kind of thing can be done in a new country like America, why cannot something of the same kind be done in a rich country like our own. It would be difficult to give a reason, except it be that we have not yet realised the duty that lies upon us to train up all our future citizens in the way they should go.

The matter has been brought under the notice of the heads of the Education Department, and they are said to be "considering" the matter; but those who know the ways of the Department and our system of government are well aware that matters of this kind take a deal of consideration before action results.

Public opinion has to be formed, and influence brought to bear; and it is for this reason that I have ventured to bring this matter before you, in the hope that, if you have the opportunity, you will lend a helping hand.

Till a full national scheme is organised, our local institution is always open to receive donations towards the founding of scholarships, either for technical training or more advanced general education, and if any Crœsus in the West of Scotland is disposed to help the deaf towards this higher education that some of them desire, I shall be happy to indicate in what direction I think help may be given.

In conclusion, allow me to say that I had hoped to have made this survey of the work much wider and more comprehensive, to have said something of the work that is being carried on in Europe, to have noticed the efforts which are being made to

spread the work in our colonies, in India, and even in China and Japan, but the worries incidental to and inseparable from the management of a large institution, the largest of its kind in Scotland, during a time of exceptional sickness and trouble, have prevented me from carrying out my original design as fully as I would have liked to do. I trust, however, that what I have said will have proved of some interest to the members of this body, and that the kind sympathy which is always extended towards the deaf and dumb themselves will be also extended to the many imperfections of this rather scrappy paper.

XII.—*On the Bubonic Plague.* By Dr. ALEX. R. FERGUSON.

[Read before the Society, 20th April, 1898.]

IN bringing a subject of this kind before the notice of this Society, I feel that it is one in which interest and concern are alike awakened—those calamitous events recently seen in India, in connection with the disease of which it treats, constituting its most emphatic claim on our consideration.

Of the many epidemic forms of disease by which different parts of the world have been at one time or another dominated, to the extent almost of depopulation, none have been so long known, so strenuously guarded against, or so much dreaded, as that known as the Oriental or Bubonic Plague.

Although evidence is not wanting that the disease had been known in certain parts of India and China practically from time immemorial, yet amongst the earliest records, the details of which are sufficient to enable the nature of the disease to be determined, must be mentioned those which refer to a pestilence occurring in Lybia, Syria, and Egypt in the third century B.C. It apparently made its appearance in Europe in the sixth century A.D., when certain parts of the Roman empire were invaded by it. Indeed, it had not disappeared from Italy and its subordinate provinces until, by means of very widespread sources of infection, the whole of Europe was submerged by what may be literally termed a tidal wave of death in the fourteenth century, whereby it is estimated that not less than 25,000,000 persons perished. All are now agreed that the *Black Death*, or "*Great Mortality*," as it was called in Southern Europe, which so completely overcasts the history of this century, is identical in its features with a very fatal and highly infectious form of plague still present, though happily on the wane, in Bombay. There is little doubt that the main source of infection causing this mediæval epidemic originated in China, though plague centres in India may have

contributed to its spread. From these *foci*, especially the former, infection was carried along the main caravan routes. From China, these ran through Central Asia, keeping well to the north of the Caspian Sea, and thence by way of one of the Black Sea ports to Constantinople, which at that time constituted the main centre of communication between Asia, Europe, and Africa. Europe was thus exposed simultaneously to a source of infection travelling in a westerly direction overland from the south-east portion of Russia, and to infection borne to its various ports by trading ships from Constantinople. Other caravans went from India through Asia Minor to cities along the southern margin of the Caspian Sea, so that a European infection from Indian plague centres also is more than probable.

Numerous epidemics of plague, which continued to be recorded in the fifteenth and greater part of the two following centuries, show with what difficulty the disease was eradicated from European soil, and it was only towards the close of the seventeenth century that it receded slowly eastwards. In London, as is well known, it raged unchecked till the great fire of 1666, which removed to a large extent its haunts of infection, but did not extinguish it, sporadic cases occurring in the city and district till 1679.

It is worthy of note that plague finally disappeared from Europe in that district into which it had been at first imported, viz., the south-east of Russia. Plague as an endemic disease only vanished completely from Europe in 1878-79, up to which time certain villages on the Volga had been subject to periodic outbreaks of the infection.

In certain parts of India and China, however, plague has never been wholly extinct, the records of both countries showing the occurrence of epidemics at intervals of a few years from the earliest times to the present day.

With regard more particularly to Bombay, which, as is well known, has been infested with plague certainly since the beginning of September, 1896, and probably earlier, authorities are generally agreed that, as an endemic condition, it does not exist in this city. It is, therefore, necessary to determine by what route it may have reached Bombay. Without considering in detail the other possible sources of infection, it will suffice for our purpose to state that in all probability Hong Kong must be, in this instance, regarded as the "*fons et origo*" of infection.

XII.—*On the Bubonic Plague.* By Dr. Alex. R. Ferguson.

[Read before the Society, [illegible] April, [illegible].]

In bringing a subject of this kind before the notice of this Society, I feel that it is one in which interest and concern are alike awakened—those calamitous events recently seen in India, in connection with the disease of which it treats, constituting its most emphatic claim on our consideration.

Of the many epidemic forms of disease by which different parts of the world have been at one time or another dominated, to the extent almost of depopulation, none have been so long known, so strenuously guarded against, or so much dreaded, as that known as the Oriental or Bubonic Plague.

Although evidence is not wanting that the disease had been known in certain parts of India and China practically from time immemorial, yet amongst the earliest records, the details of which are sufficient to enable the nature of the disease to be determined, must be mentioned those which refer to a pestilence occurring in Lybia, Syria, and Egypt in the third century B.C. It apparently made its appearance in Europe in the sixth century A.D., when certain parts of the Roman empire were invaded by it. Indeed, it had not disappeared from Italy and its subordinate provinces until, by means of very widespread sources of infection, the whole of Europe was submerged by what may be literally termed a tidal wave of death in the fourteenth centu[illegible] whereby it is estimated that not less than 25,000,000 [illegible] [illegible]hed. All are now agreed that the *Black Death*, or [illegible] [illegible]lity," as it was called in Southern Europe, whi[illegible] casts the history of this century, is iden[illegible] a very fatal and highly infectious f[illegible] though happily on the wane, in Bo[illegible] that the main source of infection [illegible] originated in China, though pl[illegible]

contributed to its spread. From these *foci*, especially the former, infection was carried along the main caravan routes. From China, these ran through Central Asia, keeping well to the north of the Caspian Sea, and thence by way of one of the Black Sea ports to Constantinople, which at that time constituted the main centre of communication between Asia, Europe, and Africa. Europe was thus exposed simultaneously to a source of infection travelling in a westerly direction overland from the south-east portion of Russia, and to infection borne to its various ports by trading ships from Constantinople. Other caravans went from India through Asia Minor to cities along the southern margin of the Caspian Sea, so that a European infection from Indian plague centres also is more than probable.

Numerous epidemics of plague, which continued [illegible] in the fifteenth and greater part of the two following centuries, show with what difficulty the disease was eradicated from European soil, and it was only towards the close of the seventeenth century that it receded slowly eastwards. In London, as is well known, it raged unchecked till the great fire of 1666, which removed to a large extent its [illegible] of infection, but did not extinguish it, sporadic cases occurring [illegible] till 1679.

It is worthy of note that plague finally disappeared from Europe in that district into which it had been [illegible], viz., the south-east of Russia. Plague as an [illegible] vanished completely from Europe in 1878-79, [illegible] certain villages on the Volga had been subject to [illegible] outbreaks of the infection.

In certain parts of India and China, however, plague has never been wholly extinct, the records of both countries showing the occurrence of epidemics at intervals of a few years from the earliest times to the present day.

With regard more particularly to Bombay, which, as is known, [illegible] infested with plague [illegible] 1896, and [illegible]

This is supported (1) by the fact that plague was certainly prevalent in Hong Kong at the time, though not in such an actively epidemic form as a year or two previously; (2) that many persons resident in Bombay, who had travelled to Hong Kong on business, were allowed to return to the former city; (3) that, apart from passengers, ships are peculiarly liable to convey infection by harbouring rats, these animals being, as we shall afterwards note, peculiarly susceptible to plague; and (4) that the disease in Bombay made its earliest appearance amongst a certain class of men employed at the Bombay docks in connection with the Hong Kong steamers.

Before proceeding to a short description of the symptoms oi plague, it will be well to mention that plague cases of all kinds may be conveniently divided into—

I. Cases of all degrees of severity characterised by buboes.

II. Cases of pneumonic type, giving rise to an illness very like an extremely acute inflammation of the lung.

III. Cases of an abdominal type, producing an illness resembling in many respects typhoid fever.

I. In the first variety, or bubonic plague strictly so-called, the patient feels feverish, out of sorts generally, and complains of pain in one axilla or groin. The seat of pain, which is at first red and exquisitely painful to touch, shows in the course of a few hours a tense swelling. This is connected with the abundant lymphatic glands of the region affected, and undergoes in later stages a considerable enlargement and softening. Many other glands become similarly involved within a comparatively short time, and, with a general aggravation of other symptoms, the patient's condition has become critical.

II. In the second, or pneumonic variety, the symptoms are those of the onset of an acute pulmonary disease, and differ in no striking respect from those which usher in an attack of pneumonia, the degree of fever and illness of the patient being, however, out of all proportion to the lung mischief present, which may be relatively insignificant. We may note in passing that the vast majority of cases occurring in the fourteenth century were of this type, the description of symptoms at that time, both by medical and non-medical writers, constituting a graphic picture of the

condition as seen at present. One of the medical writers* of the sixteenth century thus speaks of it as

> "A dreadful pest, before unknown,
> Which seized the lungs, and made the breast its throne,
> Four days it tyrannised with dreadful sway,
> When life in purple streams broke out and fled away."

The expectoration of blood in this form is an early and tolerably constant symptom, and it is to this fact probably that reference is made in the latter part of the above quotation.

III. Cases of the abdominal type of infection have only within comparatively recent times been differentiated, and probably for this reason, as well as their close resemblance to certain other forms of abdominal disease, especially typhoid fever, and some of the remittent fevers of India, constitute a minority of the cases of plague recently seen. Thus it is more than probable that a certain proportion of cases certified as remittent fever, which underwent a sudden and notable increase during the prevalence of plague in Bombay, must be placed within the category of the latter disease.

From a general survey of the facts just detailed, the conclusion is not difficult to reach that the specific cause of this long-known and much-dreaded scourge is some form of living *contagium.* This was felt to be the case more than sixteen years ago—long before the discovery of an organism associated with the disease was announced. At this period Dr. Hirsch, of Berlin, maintained that, for the development of the disease and the formation of a plague centre, there is always required the access of the specific virus of plague, and that these centres are co-extensive with the limits of diffusion of the virus. This opinion, shared by many, has received since 1894 the fullest confirmation in ascertained fact. In this year the announcement of the discovery of a specific micro-organism as the cause of plague was made independently by Kitasato and Yersin, whose researches were carried out at Hong Kong during the then prevailing epidemic. The organism, which is now well known in many laboratories at home and abroad, has the form of a minute rod, and is usually, therefore, termed the plague bacillus. In comparison with most

* Fracastorius.

of the other disease-producing bacilli, that of plague may be spoken of as a short, thick bacillus. An approximate idea of its dimensions may be conveyed by the statement that 10,000 of them placed end to end, or 25,000 side by side, are required to cover a linear inch. The bacillus has distinctly rounded ends, and stains well by any of the simple aniline dyes in common use, *e.g.*, fuchsin or gentian violet. A fact to be noted in stained preparations of the bacillus is that the terminal portions of the rod are stained much more deeply than the central zone—a characteristic to which the term "polar staining" is applied. Further, the existence of a capsule of quite appreciable breadth, in the form of a faintly-stained homogeneous envelope surrounding the deeply-stained poles of the bacillus, can usually be determined. As in the case of other encapsuled organisms, however, the bacillus loses this structure when grown under artificial conditions in the laboratory. The bacillus has no inherent power of motility, and careful examination has failed to reveal the existence of any mechanism, *i.e.*, flagella, by which locomotion might be possible. The existence of spores also has not been demonstrated. In common with the other members of the large class of organisms to which it belongs, its multiplication is caused by fission—a slight increase in length—and the appearance of transverse septa or divisions characterising the bacilli during the process. Each of these subdivisions afterwards becomes free as a young bacillus, capable of undergoing the same change. This process, even under artificial conditions, proceeds with incalculable rapidity. Several of the characteristic features of the bacillus, to which attention has just been directed, are well illustrated by this micro-photograph [photograph handed round], taken by Dr. Bitter, of Cairo, and by the lantern slide prepared by Dr. Arch. Young in the Pathological Institute of the Western Infirmary. [Slide shown on screen.] The growth of the bacillus takes place readily on the usual nutritive media of the bacteriological laboratory, especially on ordinary peptone agar. On the latter medium, after 24 hours' incubation at 100° F., the growth is apparent as a greyish-white, moist-looking film, not unlike that of the bacillus of typhoid fever recently shown at a meeting of this Society, but differing somewhat from this in the fact that the separate colonies of the bacillus are dotted over the surface of the medium in the form of minute round plaques, which only become confluent towards the lower portion of the tube. [Culture shown.]

The activity of the growth of the bacillus, although vigorous when freshly implanted on artificial media, declines steadily in course of time, so that a re-inoculation on a fresh tube of nutrient agar, from one containing a culture whose age is three weeks or thereabout, frequently proves incapable of perpetuating the growth. Along with this diminution in power of growth a notable decrease in degree of virulence is observed, and it is not too much to say that a laboratory culture of the plague bacillus, obtained by successive inoculations from a parent stock, possesses little, if any, actively virulent power. As a point of considerable practical importance, it is to be noted that while the bacillus is capable of growth at a comparatively low temperature (60° F.), yet it is easily destroyed by heat—two hours at a temperature of 136° F., or a few minutes at 212° F., sufficing for this purpose.

In the body of an infected person the bacillus is found, as a rule, in situations corresponding closely with the morbid conditions which it produces. Thus, in the buboes or swellings of lymphatic glands, which characterise the majority of plague cases, the bacillus occurs in immense numbers, and virtually in a condition of pure culture, while in the spleen they are fairly numerous.

In cases of the pneumonic type the lung *alveoli*, or air-cells, and expectorated matter contain the organism in abundance.

It is only in very severe and rapidly fatal cases in the human subject that they can be found in the blood during life by microscopic examination. In the blood of the smaller rodents, however, the bacillus can be demonstrated in immense numbers.

The division of cases of plague into the three clinical types which we have mentioned—viz., the bubonic, the pneumonic, and the abdominal—correspond generally to three possible modes of invasion of the body by the bacillus. These are—

I. *Through small wounds and abrasions of the skin.* In this way one or two medical men have suffered during the epidemic still in progress in Bombay, having been inoculated through wounds received while making *post-mortem* examinations in plague cases. Experimental inoculation of the disease in monkeys showed that they contracted it typically, though the point of entrance of the virus could scarcely be detected with the naked eye.

II. *By inhalation*, in which case, naturally, the pulmonary system bears the brunt of the infection.

III. *By ingestion with the food*, in which the mesenteric glands associated with the intestine are involved.

In reading the records of plague, as seen both in ancient and modern times, we are driven to the conclusion that dirt, overcrowding, and defective drainage have everywhere, and at all times, co-operated as a powerful alliance in its propagation.

In these respects, "a more favourable hot-bed for the development and dissemination of the disease could neither possibly exist nor be imagined than the town and island of Bombay." This applies, with particular emphasis, to the native quarter, in which plague first broke out. "These are to a great extent built on "made soil," much of which was originally impure material, including what has been used in reclamation in the vicinity of the docks. Blocks of buildings, several storeys high, were rapidly run up some years ago without proper connections with the sewers, and only surface drains in many places to carry off the surplus sewage and soakage which the ground could not absorb, the solid excreta being removed in baskets on sweepers' heads to the nearest night-soil cart, which, when full, is drawn by bullocks, to be emptied into the main drain at Carnac Bridge or elsewhere. The pollution of soil and atmosphere in such circumstances may perhaps be better imagined than described." *

In concluding this paper, which presents merely an outline of the subject, a reference must briefly be made to the results obtained by a mode of treatment now much in vogue in connection with specific infectious diseases of all kinds. In order better to comprehend the nature of this mode of treatment, allow me to call your attention to such facts as the following:—Cultures of most pathogenic microbes, after being grown under not altogether favourable conditions, undergo a certain diminution in virulence, so that, when introduced into the body of a susceptible animal, the effect produced is very much less than that which follows an injection of the same organism under other circumstances. Such cultures are said to be "attenuated." It has been found, for example, that a series of injections of cultures of the cholera spirillum, of successive degrees of attenuation, is followed by a

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* *Brit. Med. Jour.*, Feb. 13, 1897.

condition of comparative immunity against cholera. In other words, the injection of what was formerly a lethal dose of a culture of normal virulence is now followed by a slight, transitory effect, or even by none at all. "Such a method can be preventive, but can never be curative, as the immunity must be developed before the onset of the disease. Immunity of this kind is comparatively slowly produced, and lasts a considerable time, though the period varies in different cases."* Again, if a high degree of immunity be conferred on an animal by the method above described, it is found that the serum of such an animal is capable of exerting an antagonistic or neutralising influence when injected into another animal along with the organism (or its products) in question. The serum of the immunised animal is thus capable of conferring a certain degree of immunity on another animal. It is important to note that this immunity is conferred even though the second animal has been infected before receiving the injections of serum. This latter method has thus a curative action.

Haffkine's mode of treatment, which is entirely prophylactic, is based on the first of the methods described. Its aim is the establishment of a certain degree of immunity against the plague by means of injections of cultures of the plague bacillus, whose vitality has been destroyed by subjecting them to a temperature of about 60° C. It is gratifying to note that of 8,142 persons treated by this method in Bombay up till October, 1897, only 18 were attacked by plague.

The results given in connection with Yersin's anti-plague serum are equally encouraging, though the precise value of both methods must be based on results involving their greatly extended application.

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*Muir and Ritchie, "Manual of Bacteriology."

XIII. — *Some Scientific Questions concerning Pictures.* By ARCHIBALD BARR, D.Sc., Professor of Engineering, Glasgow University.

[Read before the Society, 9th February, 1898.]

SOME scientific questions concerning pictures! I have no doubt that many persons, including, it may be, most artists, on hearing this proposed as the topic for a paper, would be disposed to say, "The author has no subject, there are no such questions, science has no kinship with art, and can have no bearing upon art in any of its forms."

I do not propose to attempt to define art either in the abstract or in any of the manifold forms in which it embodies itself, but I think we may take it that art is a something, or some quality, that has to do with the manner in which the conceptions and perceptions of one mind may be realised in concrete form and presented to other minds. If this be what we mean by art, then it appears to me that any view of art that would leave no place in its sphere of operation for bearings upon each and every department of human knowledge, and each and every aspect of human thought and feeling, is a narrow view, and one that would lower art from the high pinnacle that may be justly claimed as its proper seat. The elevation of art above the realm of the purely matter of fact is an elevation, not of icy isolation, but of ascendency and transcendency. Any theory, or—if a theory is here an impossibility—any conception, of art as independent of knowledge, seems to me to be a degradation of that which it would apotheosize.

Without being an idealist or a nominalist, one may, I think, hold that art has no existence outside or apart from the mind of man, and it must be related in each mind to the knowledge which forms the basis of the impressions of which that mind is capable. To whose mind, then, should a work of art appeal, since "each man has, or thinks he has, a mind and ideas"?

Let us consider the question for a few moments with a text to work from.

In his remarkable—I would say extraordinary—lecture, to which he has given the curious, though suggestive and reminiscent, title, "Ten o'Clock," Mr. Whistler says of Art—"She is a goddess of dainty thought, reticent of habit, abjuring all intrusiveness, purposing in no way to better others. She is, withal, selfishly occupied with her own perfection only, having no desire to teach."

And of Rembrandt, Tintoret, Paul Veronese, and Velasquez, he asserts, "No reformers were these men—no improvers of the ways of others."

Now I make bold to say that neither in these words themselves, nor in the working out of this section of his theme, did Whistler express any truth fully or clearly. Perhaps, indeed, in conformity with the theory of art which he *seems* vaguely to enunciate, he had no desire to teach, or to improve, no intention to appeal to any intelligence on the part of his Oxford audience. He may accordingly have intentionally clothed his doctrine—if he had one—in a ten-o'clock-of-the-evening obscurity.

But I think one cannot be far wrong in assuming that his doctrine, so far as it is hinted at, amounts to the claim of "art for art's sake," and affords one answer to the question we have asked, in the assertion that art has no desire to appeal to any mind save possibly that of the artist himself.

Punch's young artist gave us a much more definite, if less poetical, statement of this doctrine when he exclaimed—"High art is for the few, not for the many; the higher the art the fewer the few; the highest art of all is for one, and that for myself."

There is a form of art, so called, which many of us have no desire to recognise as within the sphere of our ideas of the beautiful. As Sir E. J. Poynter has indicated, the tendency of the modern French School in Art is towards too exclusive devotion to *treatment*, and the result has been that the French "have almost arrived at the conclusion that one object is as good to paint as another—a female head or a piece of raw meat being looked upon as equally suitable for the exercise of the skill in painting."

Not so with the greatest artists of this or any other age. They have had their missions, and they are great in the measure in which they have fulfilled them, whether these missions have been purely æsthetic or of that higher order that combines the æsthetic with the ethical. Verily they have been improvers of the ways of others. Their works do appeal to men, and appeal alike to the

learned in art and to the unlearned. Like the great in every sphere of human activity, they are great in as much as—

> "They wrought a work which time reveres,
> A pure example to the lands,
> Further and further reaching hands
> For ever through the coming years."

Watts, undoubtedly one of the greatest of our modern painters, has given us a statement of his own artistic aims:—"My intention has not been so much to paint pictures that will charm the eye, as to suggest great thoughts that will appeal to the imagination and the heart, and kindle all that is best and noblest in humanity. I teach great truths—I appeal to men of all ages and every faith."

And has an adverse criticism of his own work as having a moral significance not called forth from one of the greatest artists of any age—Alfred Tennyson—words, perhaps, the most burning he ever wrote—

> "Art for art's sake! Hail truest Lord of Hell. . ."

He, like Watts, devoted his life to "Art for art's sake—and man's."

Not, indeed, by any means, that every work of art, to be a great work, must have a lofty theme or a moral lesson, but surely to elevate mere craftsmanship over the conceptions it clothes, the truths that it embodies, and the influences it may exert—nay, to condemn a work of art for having a high theme and a noble purpose—is verily an exaggeration of the vulgar error—

> "To give to dust that is a little gilt,
> More laud than gilt o'er dusted."

Leaving these general observations regarding the ends and aims of art, let us examine the connections with art of the external facts and phenomena which form the basis of its concrete expression.

I shall take another text from Whistler, not that I understand that his words will be universally accepted as a gospel of art by artists—we should search long enough, I fancy, for any accepted canon—but because he is justly considered a great artist, and he has given us words which, we may assume, represent at least *an* artist's creed. *These* words are as clear as noonday:—"Nature contains the elements, in colour and form, of all pictures, as the keyboard contains the notes of all music. But the artist is born to pick and choose, and group with science, these elements, that

the result may be beautiful—as the musician gathers his notes and forms his chords until he brings forth from chaos glorious harmony."

Yes, to pick and choose and group, that the result may be beautiful. But beautiful to whom? Who is to set a criterion of the beautiful? If it is each artist for himself, then all considerations or criticisms of art, from whatsoever source they come, are vain, and the veriest daub may be the highest work of art, since it is the poorest artist who is most certain to have the fullest conviction of the perfection of his own work.

No! Art, to be art, must appeal to some audience beyond the artist himself. But it may be argued that art to be true art need only appeal to those who have made it their special study. I do not think that this is altogether true, but granted—and indeed it is a part of the argument I would desire to enforce—that a perfect acquaintance with art would be essential to the full appreciation of the merits of a perfect work, it may still be true that a perfect knowledge of art would involve a perfect knowledge of everything else that is knowable. It is the acceptance of this view, it appears to me, that will raise art to its true place—and that a high one—among the vocations of men. This is what I would understand as the true meaning—whether or not it is the intended meaning—of the words I have quoted. The artist is to pick and choose and group with science—with knowledge, I take it, not of the technique of art alone, but of all that appeals to the senses of man. Therefore, I repeat, art to take its proper place must have a connection, and an intimate connection, with each and every department of knowledge, and with every aspect of human thought and feeling; and it is to the mind that has a competent knowledge on the one hand of everything that concerns the external realities and the ethical principles with which art deals, and on the other of the traditions of the craft and the aspirations of the craftsmen, that a work must appeal in order to be worthy of general acceptance as masterly. I would I had sufficient knowledge of art to enable me to speak from that side on the bearings of scientific truth or falsehood on the artistic value of pictures. I shall, as far as possible, allow artists to speak for themselves. But this far, at least, we may surely go on the most general considerations—and we may be able to illustrate the dictum in various ways—that any work that depends for its effect upon the *ignorance* of the audience is, in so far less worthy,

less perfect, than one that depends upon inherent truths. The only question may be what is *truth* in respect to art.

Now it seems to be assumed by artists that the alpha and omega of such ideas regarding art as are held by those who are without its pale, in the professional sense, are expressed in a demand for transcriptions of natural scenes and actual events as literal as the materials of the art will permit. If I may be bold enough to speak in the name of the students of science, I will assert that this assumption is as unfair and as untrue as would be the assertion that the artist's ideal masterpiece of architecture, or of any other of the constructive arts, would be a work that had some kind of beauty of form, with an utter indifference to all considerations of utility or of structural fitness of design.

It is indeed instructive to note that the most hard and uncompromising expressions of this theory of art come from the artists, not from the students of science. It was Leonardo da Vinci who propounded the theory in so many words that "the looking glass is the master of painters,"* and it was Shakespeare, who, in regard to another form of art, puts these words in the mouth of the spokesman—

> Its end "was, and is, to hold, as 'twere, the mirror up to nature."

But, fortunately for art, neither they nor any other artists of note have practised, in any literal sense, the doctrine thus announced.

No, it is not that view that will meet with the approbation of the art-loving student of science, but the view already quoted from the later master—"Nature contains the elements in colour and form of all pictures," but "the painter is born to pick and choose and group with science, that the result may be beautiful."

We set aside then at once, and for good, the idea that art reaches its highest perfection when it succeeds in producing the most realistic and illusive representation of some natural objects or aspects. Such a view, at the very best, would make perfection depend only upon the extent to which the artist has succeeded in depicting what he has chosen to represent—not at all on the nature of the choice. It would be a laudation of the "raw meat" order of pictures, the very existence of which to-day—nay, more to-day, perhaps, than ever before—shows that it is among artists themselves that literal and realistic transcription is looked upon as

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* May we not read "photographic camera" for "looking glass" to give these words a modern rendering?

manifesting the artistic power. All worthy pictorial art consists more in the matter than in the manner of the work, just as true poetry consists more essentially in lofty thoughts and noble conceptions than in smoothly flowing lines and faultless rhymes—however essential these may be to the highest perfection of the finished work. "The greatest artist," says Ruskin, "is he who has embodied the greatest number of the greatest ideas." Art, therefore, finds its richest field of labour in the imaginative side of its work; a great picture should be a great invention, as well as a cunning piece of craftsmanship.

A picture may indeed deal with a certain scene or a certain incident. Its ostensible object may be to convey an impression of the grandeur and sublimity of some special aspect of nature, or of the actual facts of a particular historical event. In such cases it may be a question how far the artist may legitimately depart from literal truth. To fix our ideas, suppose the subject be the "Death of Nelson." Now, while the artist is free to select the moment most suitable for pictorial treatment, we may reasonably demand that he will spare no pains to paint the scene, *in all essentials*, as truthfully as it is in his power to do. Such a picture makes a statement as regards a fact in history, and we may rightly demand of the painter the truth as regards all matter of fact essentials in the portraiture of the principal personages, the delineation of the uniforms, and the presentment of the actual surroundings; and all physical impossibilities or anachronisms will fairly lay the artist, as they would the historian, open to criticism. Historical pictures should be as literally true, *as regards the impression they convey*, as historical records of any other kind. For this reason we may, and we do, demand, for example, of the artist who would deal with scenes of ancient history, a competent knowledge of archæology and of recorded facts.

There are, however, important intrinsic differences between pictorial and written historical records. In the first place, the historian may omit from his word picture all references to incidents and accessories of which he has no sure knowledge, or which he considers it unimportant to record. We clothe his sketch in an environment of our own imagining, and to enter into minute and trivial details would be mere pedantry and wearisome padding. On the other hand, the painter must invent for himself, and for his audience, the incidentals of the scene, in so far as they are not come-at-able by any more legitimate means. One con-

spicuous example may suffice to illustrate this point. In the written records of the Institution of the Lord's Supper, we are told little regarding the attitudes of the guests, or the furnishing of the table spread for their reception. But Leonardo da Vinci, in transferring to the wall of the Refectory of the Milan Convent his conception of the scene, was compelled to invent an infinitude of unrecorded features. Considering the state of art and of knowledge in the fifteenth century, we should be unjust alike to the artist and his immortal work on the one hand, and, on the other, to our own feelings of reverence and respect for the past, were we to cavil at the European traits of the conception. We are content to admire the masterly treatment of the features chosen, and to be thankful to believe that the master gave us the scene in the noblest form in which he could clothe the meagre materials. But should any artist to-day attempt to depict that sacred scene, he would lay himself open to condemnation as culpably ignorant or false, and his work to ridicule as absurd, however masterly its technique, were he to treat such a theme with utter disregard of Eastern manners and customs. And, indeed, no modern artist, worthy of the name, would now be guilty of such inaccuracies. He would make himself more or less familiar at second hand with the manners and customs of the land in which his scene was laid, did he not indeed study on the spot all he could find to throw light on his subject, as did Mr. Holman Hunt, with so much labour, hardship, and danger, for his famous picture of "The Scapegoat."

We shall see, however, that this latter-day respect for truth of treatment has not yet pervaded the artistic world in respect to elements much more certainly and easily ascertainable than those pertaining to the manners and customs of the ancient Jews.

But to descend to more modern instances. Most people have, no doubt, admired the beautiful and graphic lines of Wolfe on "The Burial of Sir John Moore." In that word picture we are told that the weary work of laying the warrior to rest was performed "by the struggling moonbeams' misty light." Here we have a definite statement, and one, be it noted, that the poet had no call to make, save possibly, in his own view, for the sake of pictorial effect. But the "Nautical Almanac" shows, beyond the shadow of a doubt, that the moon was new on the morning of the battle of Corunna, and could therefore have borne no part in the solemn obsequies that followed "at dead of night." Now, we may be much more disposed

to smile, or even to sneer, at the inquisitiveness and pedantry of the critic, whoever he was, who unearthed this information, than to frown upon the poet who trusted to his imagination for his facts. Still we are not precluded by this sentiment from expressing the view that the poem would have been still greater than it is had it recorded, *in equally poetic language,* the truth that even the kindly help of the moonbeams was withheld from the toilers. In that case the lines would have appealed alike to the artistic sense of the lover of poetry, and to the regard for truth which must characterise the students of history or of science.

I refer to this example of poetic license in no spirit of cavilling hypercriticism, but merely in order to point the argument which I am following, that pictures may not be enhanced in beauty, in the eyes of any one, by the introduction of untruths and anachronisms, while their effectiveness, in the eyes of those who happen to know, may thereby be reduced—possibly vastly reduced.

But let us look a little more closely into the source of the feeling of toleration, which everyone must share, in a greater or less degree, for such misrepresentations of facts. One who had taken part in the solemn rites would at once have seen the inaccuracy. Why did we not at once rebel against the falsehood? Simply because we saw nothing incongruous in the suggestion of there having been moonshine on the night of the 16th January, 1809. But suppose that a painter, gifted with a lively, and, let us grant, a lofty, artistic imagination, should give to the world a picture, masterly in technique, of the Battle of Waterloo, and should, either from carelessness or of deliberate motive, represent the conflict as taking place in a snow storm, would we be equally tolerant? I think not. And why? Simply and solely because we have reason to know, or at least to believe, that it was not winter on the 18th of June, 1815. It is then simply and solely a matter of knowledge. We tolerate in poetry or in pictures statements or features which we have no reason to know or to feel to be untrue, and leave ourselves free to admire the art with which these features are portrayed, but we—all of us, artists and laymen alike—will be prepared to condemn any absurd device for attaining a so-called artistic effect as soon as the absurdity of the device is sufficiently manifest.

But there is another and, for our present discussion, more important and fundamental distinction between the two kinds of historical record than that to which I have referred. The

historian is unlimited as to time and space. He may, without any departure from literal truth, fill up his word picture with any succession of events, and again he may bring into it any elements he chooses, however these may have been scattered in space around the central figures of the scene. The painter, on the other hand, is limited, by the nature of his art, to a single instant of time, and to a very limited field of view. Even assuming, then, that the painter's object is to convey to the utmost of his ability and knowledge as truthful an impression of his subject matter as the limitations of his art will permit, he may—indeed, he must—bring within the limits of his picture elements which, in the actual event, were scattered both in time and space. Here the painter, even of scenes from contemporary history, has a wide and legitimate field for the exercise of his powers of idealisation and design. His work need not be, and should not be, any mere coloured instantaneous photograph, so to speak; he can give us a much more truthful impression of the event or scene as a whole, than such transcript of the momentary aspect of a section of a spectator's field of view would convey. But such a gathering in of scattered elements may readily be carried too far, and may lead to absurd and impossible combinations, as in this picture of Joshua commanding the Sun and Moon to stand still. Here you see Joshua assuming an attitude of command, while he turns his back upon the sun and the full moon, which are brought into close proximity to each other in the background of a picture lighted from the front.

No doubt there was a time when the audiences to whom the painter desired to appeal could not be trusted to imagine much for themselves, and artifices such as that just instanced may have been more necessary at one time than they now appear to be. So much, at least, would be indicated by the immense advance that has been made in the representation of *ideas*. Take, for example, this rendering of the simile of "the mote and the beam." You will observe that the artist has introduced a wall for the support of the other end of the enormous log. A somewhat less literal rendering would nowadays appeal more strongly alike to the artist and his audience.

We turn more particularly to the consideration of such details in pictures as deal with objects or phenomena, the facts regarding which fall within the sphere of natural history or natural philosophy.

How far should one look for literal truth in regard to the treat-

ment of these elements in pictures, and how far should we expect the artist to make himself familiar with the facts concerning them?

I daresay that there are many artists and many laymen who, while they may be disposed to grant that art should not be considered as independent of the truth in respect to the aspects of nature with which it deals, nevertheless hold the view that the study of science, as such, is fatal to true artistic perception. That this is a fallacy—or, at least, by no means an essential truth—can, I think, be sufficiently proved by appeal to great examples. May we not instance once more the case of one who has been called the poet of science? Did Tennyson's wide study of the facts and generalisations of physical science (for such he made) dull his perception of the beautiful? Did it trammel his mind and render his work less truly imaginative and artistic than it otherwise would have been? We find him "deep in Lyell's Geology," with what result? He writes such lines as these:—

> "There rolls the deep where grew the tree,
> O earth, what changes hast thou seen,
> There where the long street roars hath been
> The stillness of the central sea.
>
> The hills are shadows, and they flow
> From form to form, and nothing stands,
> They melt like mists, the solid lands
> Like clouds they shape themselves and go."

Are these words less beautiful than any such references to everlasting hills and changeless seas as would be the result of casual and unscientific observation? Are they not, from the very fact that they embody truths that will appeal in all time to those who know, more beautiful than any false picture?

Not that Tennyson always portrayed the *actual* as distinguished from the *seeming*. Like all true artists, he paints what *appears to be* and not what *is* when he is dealing with impressions, but he never published a line, so far as I am aware, that will convey a false impression.

Passage after passage might be quoted from among the finest lines that Tennyson wrote to show the inspiration that his study of science supplied; and in all his writings I can recollect no words that are not literally true to nature, with the exception, perhaps, of those in his poem of Anacaona, published for the first time in the Memoir. We are told that he liked this poem, but would not publish it, one of his reasons being that it contained

elements untrue to natural history. Would that all artists had such love for truth and for the greatness of their art!

And to turn from the artist to his audience. Is the student of science, who reads in Tennyson's lines a most vivid picture of the past and future of the physical world as revealed to him by science, less able, on that account, to appreciate the consummate art with which the picture is drawn, than one who knew not what truth or falsehood they might contain, though he might be able to scan the lines and expatiate on the justness of the quantities and the musical sequence of the vowel sounds?

If the artistic value of Tennyson's lines has no connection with the truth of the images, and the clearness with which they are expressed, then I suppose we must raise to an equal level of art such lines as these, which *seem* to deal with a somewhat analogous imagery—

> "O, to be wafted away from this black Aceldama of Sorrow,
> Where the dust of an earthy today is the earth of a dusty tomorrow."

Or did Michael Angelo's close study of the anatomy of the human form render his drawing pedantic or ungraceful? Is it not his very truth to nature, and his power of so arranging *true* forms and colours "that the result might be beautiful," that makes his work the most masterly of its kind? Why, then, will artists not see that truth to nature in other forms with which they deal is not incompatible with the highest development of the true creative faculty?

It would, indeed, argue an utter ignorance of the nature of art were anyone to claim that familiarity with the facts and phenomena of nature, as revealed by science, will, or can, of itself create the artistic perception. Nor can science deal at all with the most important elements of artistic effect. In regard to music, science can explain and specify what notes will form true chords, but can go little, if any, further towards the discussion of questions of musical grouping of notes, and chords, and tones.

Nor can scientific knowledge give one the right to criticise the artistic value of a picture as a whole. The artist who accepts the criticism of the students of science may still apply to us the lines—

> "Our friends the Reviewers, those chippers and hewers,
> Are judges of mortar and stone, sir;
> But of meet or unmeet, in a fabrick complete,
> I'll boldly pronounce they are none, sir."

All that we claim, or are concerned to claim, is that acquaintance with the facts and phenomena of nature *on the part of the artist* will not destroy his sense of the beautiful, but will rather act as an inspiration, and teach him something he may otherwise miss regarding the alphabet of his language. "Nature contains the elements in colour and form of all pictures," and while science will not teach the artist directly what is a beautiful choice, it will tell him what *is*, and therefore what he may look for, and it will help him to avoid errors which cannot enhance the merits of his work.

There is, no doubt, a deep, fundamental, and far-reaching connection between what *is* in nature and what appeals to us as beautiful. The fact that a form, a colour, or a combination, exists in nature in a large measure makes that form, or colour, or combination, beautiful. If the grass had been brown, we should, no doubt, have considered brown fields more beautiful than green ones, because our sense of fitness in colour would have been attuned to that condition. But we cannot pursue this line of reasoning. It would lead us far into the arguments for design or development, or both, in the natural world. It may, however, be observed, as very directly bearing upon our present subject, that artists of all ages have accepted the human form as more beautiful than any they could invent for themselves. So strong, indeed, is this sense, that even when the artist gives us his idea of a mythical deity such as a Jupiter or an Apollo, or an abstraction (from the physical point of view) as that of Life or of the Soul, he adheres with consistency to the forms of nature. His Hercules may have more fully developed muscles than his model, and his Venus may be more beautiful than any daughter of Eve, but they are always conceivable forms. Even when he paints the "winged god," he provides him with all the muscles required for ordinary terrestrial locomotion, but considers it unnecessary, or contrary to his ideas of the beautiful, to supply any for operation of his pinions.

Nor does the artist ever deliberately depart from the possible or the reasonable in his treatment of the human form as such. In the filling of his canvas, or in the design of his picture in respect to the balance and artistic fitness of lines and colour masses, he exercises all his ingenuity and artistic skill in the arrangement of natural and recognisable forms. Michael Angelo did not introduce in his "Cartoon of Pisa" any legs or arms that

had no business to be there, save to fill up a blank, or break up an awkward mass. Such a method of obtaining "artistic effect" would be of the kind I have referred to—it would be too manifestly absurd, if not to the artist himself, at least to his audience.

But what of inanimate nature?

It may be observed, in the first place, that it is in regard to inanimate features that nature is most constant. Nature may, and sometimes does, produce a hand with six fingers, but the artist never introduces six fingers to give completeness to his composition, though he might plead such justification. On the other hand, there never was a rainbow that was not circular (as far as the eye could tell), nor one that had any other angular magnitude or order of colours than those fixed by the nature of things, nor yet one that was not directly opposite the sun. Yet artists will create impossibilities in all these respects. Turner, who is so true to nature in some aspects of his work, would paint an elliptical rainbow instead of a circular one, if so it fitted better the limits of his canvas—as in a vertical picture of "The Devil's Bridge." Perhaps he did not notice this want of truth to nature, but others, and not laymen alone, do. I happened to be standing in front of that picture on one occasion, and overheard a celebrated artist—a late President of the Royal Scottish Academy—remarking to his companion that he thought Turner might have used a pair of compasses with advantage.

So, on another occasion, it is said, when a client remarked upon the absence of colour in one corner of a painting, Turner replied that he would soon put that right, and painted in an utterly impossible and ridiculous rainbow. Would he have introduced an extra leg or arm into a figure piece for a like purpose? And if not, why not?

Here is a picture by Rubens. It has for its subject—or at least its title—"The Rainbow." It is no doubt the picture to which Ruskin refers as having the rainbow in dull blue, darker than the sky, in a scene lighted from the side. He does not notice, however, so far as I remember, that the rainbow transgresses another law of nature—it is quite impossible as regards angular magnitude. Ruskin justly remarks that "Rubens is not to be blamed for ignorance of optics, but for never having so much as looked at a rainbow carefully." But artists are now going more to nature than they did at one time. It is said that

Gainsborough painted his landscape backgrounds from models erected on his table, composed of broken stones, dried herbs, and pieces of looking-glass; and another famous artist is said to have taken "a pot of porter and a Stilton cheese" as the originals of a castle and a rock in one of his great works.

Sir J. Norman Lockyer has told a story to the effect that an eminent artist, then living (15 years ago), had painted a rainbow practically inside out, and "when the picture was returned to him in order that the colours might be corrected, was so indignant with this attempt to interfere with this special development of 'the highest style of imaginative creation,' to use Lord Beaconsfield's words, that he charged the trifle of £20 for attempting to place the colours in the order in which monotonous nature perversely insists they shall stand."

But not only do artists take such liberties with inanimate nature, but, what is worse, they will excuse them as necessary for true pictorial effect. This is simply a confession, though not a very candid one, of the limitation of their own powers of arrangement and design—the powers that Whistler has so well said they were born to exercise.

It is precisely such a confession that is made with candour by the epitaph writer who gave us the lines—

> "His nose's cast was of the Roman,
> He was a very pretty woman;
> I couldn't get a word to rhyme with Roman,
> So was obliged to call him woman."

Will artists recognise the kinship of that great poet?

Such a limitation figure painters, with the example of Michael Angelo before them, have never recognised as insuperable. They have started with the assumption that absurdities are barred, and that they must therefore learn to group true forms with science.

I have indicated the view that artists never depart from reasonable truth in respect to the human form because they find that they have no need to do so, and that to do so would at once lower the character of their work. And so it has been with respect to *some* inanimate features. They have only required a sufficiently authoritative pronouncement to convince them that the true is at least as beautiful as the false.

For example—Claude painted his reflections wrongly; Turner

painted his correctly. We never nowadays find Claude's mistake. Every artist now knows that the reflection of a light on water should come vertically downwards in his picture, and paints it so.

Who will teach artists a similar lesson with regard to refraction? I have never, in any gallery at home or abroad, found a single picture in which the artist has taken any cognisance whatever of that phenomenon. When, for example, a figure is shown standing in water, the water is either represented as absolutely opaque, or else the figure is painted in first and the water added, with an entire disregard of its optical properties. One would have thought that a tub of water would have been an inexpensive and instructive addition to the studio properties.

It would take several papers to adequately illustrate the artistic (?) treatment of *moons*. Painters' moons are "continually disappointing the public," as Artemus Ward said of the one in his panorama, which used to hop about the canvas in a most undignified manner as soon as he turned his back. Here is one example that is perhaps unique in its absurdity—which is saying a good deal. The subject is "A View from the Planet Mars." You will observe that the artist has here given freedom and grace to his composition by representing the moons of different ages and in different attitudes—he has, in fact, illuminated them from different suns. Not content with this extra provision for the Martian day, of which we had not hitherto been made cognisant, he has given one of his moons an *actual* and not merely an apparent crescent form, as you will observe that the circle is not completed by any occultation of the stars.

A curious and interesting instance of the occurrence of such a physically defective moon in poetry is found in the "Ancient Mariner," and the case is all the more interesting because we are able clearly to trace its origin—or at least its probable origin. We find these lines in that beautiful poem—

> "Till clombe above the eastern bar
> The horned moon, with one bright star
> Within the nether tip."

In the first edition of the poem it stood "almost within the tips," and, no doubt to improve the rhythm, Coleridge substituted a false picture for a scientifically true one. Such a departure from truth can only be attributed to want of knowledge, or want of

power to express the truth sufficiently poetically. In this instance we must say *apparently* to the latter.

I must for the present omit what I should like to have said on the subjects of perspective and of contrast of light and shade in pictures. There are many points regarding these that are essentially of a scientific nature, depending as they do upon the principles of geometry, of optics, and of physiology. If I may be permitted to do so, I may venture to bring some such questions before the Society on a future occasion. I may here, however, remind you of the very fundamental and important distinction between the spheres of art and of scientific study. The student of science, as such, is concerned essentially with what *is*, the artist is concerned with what *appears to be*, or with the impression which he wishes to convey. I shall at present refer to one aspect only of this distinction—namely, the treatment of objects in motion. The artist who would represent a moving wheel, for example—as in this delightful sketch from *Punch* of "Cross Purposes"—must not represent the spokes of the wheel as they actually are, or as an instantaneous photograph would show them, but he must put in a multitude of lines to give the correct impression of the wheel as it appears when rapidly revolving. A much more important case is that of animals in motion. Forgetful of the principle above referred to, a good deal of nonsense has been written regarding the treatment by artists of trotting and galloping horses. Muybridge's most interesting photographs have shown us how horses actually move their legs, and what attitudes they assume during their strides, and some writers have blamed artists for painting horses in attitudes that they never take. But artists have nothing to do with the instantaneous attitudes of a moving animal, they must give us such attitudes as are most suggestive of the appearances the movements convey. Now, it is both interesting and instructive to notice that if a "composite" is made from a set of Muybridge's photographs—that is, if all the pictures of a set representing a complete stride be superimposed—the resulting blurred picture does suggest attitudes of the legs closely resembling those which artists such as Meissonier have depicted. It is greatly to the credit of artists that they have so carefully observed horses in motion as to be able to give a rendering, perhaps as perfect as possible, of what is essentially unpaintable. It serves further to illustrate the devotion of artists to truth of treatment in dealing with animate

nature, and makes us the more desire that they would show a like appreciation of the beauty of inanimate creation as it actually presents itself to our eyes.

As we have seen, the man of science is concerned essentially with what is, not with what appears to be, while with the artist quite the reverse is the case. And the method of science must usually be to isolate and to analyse the object of study, so as to discover what is proper to it and not to its surroundings; while the artist, in order to produce the best results in his work, must always look upon nature as a whole, and the relation of one part to another, never upon the isolated elements of his composition in themselves. The methods of the study and laboratory must be excluded from the studio; isolation and abstraction are fatal to true artistic effect. The artist may—indeed, must—analyse natural appearances and impressions, but his analysis must not be that of the scientific observer—an analysis into separate minute details—it must be an analysis into essences, into broad and comprehensive features of light, shade, and colour.

> "I thought the sparrow's note from heaven,
> Singing at dawn on the alder bough;
> I brought him home, in his nest, at even;
> He sings the song, but it pleases not now,
> For I did not bring home the river and sky:—
> He sang to my ear,—they sang to my eye.
> The delicate shells lay on the shore;
> The bubbles of the latest wave
> Fresh pearls to their enamel gave;
> And the bellowing of the savage sea
> Greeted their safe escape to me.
> I wiped away the weeds and foam,
> I fetched my sea-born treasures home;
> But the poor, unsightly, noisome things
> Had left their beauty on the shore,
> With the sun, and the sand, and the wild uproar."
>
> [*Emerson.*]

If the effect of the infusion of more of science into the world of art should be to cause the methods and attitudes of mind of the study and the laboratory to enter too largely into the studio, it had better far be rejected; but surely scientific truths can be used without being abused, and there is no danger, yet a while, of the artist becoming too much imbued with scientific knowledge or too prone to adopt the laboratory attitude of mind.

Is there not a vastly greater danger before art in the tendency,

only too prevalent to-day, alike in literature and in painting, towards a fatal dallying with subjects mean and low? Is not the claim of art for art's sake, and the pursuit of no higher aim than the display of a certain amount of cleverness in treatment, irrespective of motive, in danger of degenerating, as Tennyson has indicated, into a love of ugliness for ugliness' sake? Let us be thankful that the greatest artists are still on the side of truth and of the beauty which is embodied only in high and pure ideals. They still realise that their talents are given them to be used for the elevation and advancement of mankind, notwithstanding Whistler's declaration. One may, I think, be pardoned for preferring Whistler's practice to his doctrine.

"I even think," says Watts, "that in the future, and in stronger hands than mine, Art may yet speak, as great Poetry itself, with the solemn and majestic ring in which the Hebrew prophet spoke to the Jews of old, demanding noble aspiration, condemning in the most trenchant manner prevalent vices, and warning in deep tones against lapses from morals and duties."

XIV.—*Glasgow Cathedral: Notes from a Sketch of its History.*

By P. MACGREGOR CHALMERS, I.A., F.S.A.Scot.

[Presidential Address to the Architectural Section, 15th November, 1897.]

FOR many years I avoided the publication of material which I have for long been gathering relating to the Art and History of Glasgow Cathedral. Indeed, for a considerable time, and for a reason which seemed good to me, I laid the study aside, and devoted what leisure I had to the examination of other works in Scotland—relics of former days and of former craftsmen. These works had an interest for me, yet they lacked that strong personal interest which always pertains to a structure reared in one's native city which has been a centre of thought since boyhood. As might have been anticipated, however, the study of other buildings constantly threw light upon our cathedral. Whilst the desire to put the result of my labours in connected form has grown upon me, recent circumstances have made it desirable that the following notes should now be published.

There is probably no spot in Scotland so hallowed as is Glasgow from its association with the three greatest leaders in the effort to convert our countrymen to Christianity—St. Ninian, St. Columba, St. Mungo. These names are well known to us. It may be that our very familiarity with the names leads us to consider too seldom the greatness of the men. But his must have been a powerful and profound nature, and the work accomplished in those distant times must have been far beyond the ordinary efforts of men, when name and fame remain green amongst us after thirteen or fifteen centuries. Of all those with whom they associated, a few names only have come down to us; and yet, doubtless, if the race is to the strong, it was as hard then as ever it has been and is now. These three were of those—

> "Whom a thirst
> Ardent, unquenchable, fires,
> Not with the crowd to be spent,
> Not without aim to go round
> In an eddy of purposeless dust,
> Effort unmeaning and vain."

In the life of St. Mungo, written by Jocelin, a monk of Furness, it is recorded that the saint was miraculously brought "to Cathures, which is now called Glasgow," and that he halted "near a certain cemetery, which had long before been consecrated by St. Ninian."* Saint Ninian's presence here may not be doubted. His choice of a site for a new missionary enterprise was probably dictated by its close proximity to the local chieftain's stronghold. The chieftain's gift of a cemetery, which yet was not used until long after, points not only to the success of the mission, but illustrates how then, as in remoter and more modern times, "God's acre" is hallowed as the resting-place of the dead.

It may be that when St. Mungo came the effect of St. Ninian's mission had, to a large extent, been dissipated. Still the memory of his labours remained, and it is not impossible that the two brothers, Telleyr and Anguen, with whom St. Mungo dwelt, were teachers, grown careless. St. Ninian's fame, however, does not specially rest upon his work at Glasgow. He laboured in Galloway, and somewhere about the beginning of the fifth century, and before the Roman occupation of Britain had come to an end, he erected a church in stone, after the Roman manner. It received the name of "Candida Casa," probably from the fact that the ruble stonework of which it was built was covered with a coating of hard cement of a white colour. This was a method of construction practised in early times, as may still be seen on the walls of the crypt in the church erected by St. Wilfrid at Hexham. Of St. Ninian's Candida Casa I believe it is possible that fragments remain to the present day in the foundations of what is known to have been a small tower, and in the low walls buried in the rough heap of loose stones and earth to the west of the ruins of Whithorn Cathedral. As St. Ninian was educated at Rome, and as, on his way home, he visited St. Martin at Tours, and from him procured masons, who were to build a church for him on his return, it will be of interest to note what was the Roman model. The plan of such a church consisted of an oblong cell or nave, with a semicircular apse at the east end and a porch at the west. The outer door to this porch was, as a rule, in its south wall, and the entrance to the nave was by a comparatively large open archway. The porch, in many cases, was reared as a western tower. This plan, we find, was adopted in the Romanesque Church of St.

* Metcalfe's "Ancient Lives of Scottish Saints," p. 200.

Regulus at St. Andrews, erected, I believe, between the years 970 and 995, and also at Restennet Priory. In England it is to be seen in the churches of Jarrow and Monkwearmouth in Durham. In each of these four churches—and there are others doubtless—the fabric was enlarged at a later time by the addition of a new nave to the west side of the original western tower. The west wall of the tower was then pierced by a new archway, after the pattern of that in the east wall. The appearance of such a church, in which we can trace the first step in the evolution of the transeptal form, is well illustrated on the seal of St. Andrews Cathedral, which shows St. Regulus' Church, and on the seal of Candida Casa itself, which gives, I believe, a view of St. Ninian's Church as thus enlarged.* Although the practice is now to some extent in abeyance, in early and in mediæval times the churches were built lying east and west, with the altar at the east end. There is a legend of Dunstan, Archbishop of Canterbury, which relates that, seeing a church on the wrong axis, he placed it properly by a push with his shoulder.

St. Ninian died at Whithorn about the year 432, and was buried in his own church. The fame of the miraculous powers possessed by his relics spread over Europe. Pilgrimages to his shrine were only abandoned when prohibited and made punishable by an Act of Parliament in the year 1581.

St. Columba, who was a contemporary of St. Mungo, was born in Donegal, in the year 521. He received his education and he began his labours in Ireland under the influence of the Irish or Celtic Church, although he, doubtless, was brought into contact with the school of Candida Casa, since one of his teachers, St. Finnian of Moville, had studied there. St. Columba was excommunicated, and had to leave Ireland. The tragedy which led to this cast its shadow over the life of the saint.† He came with twelve disciples to Iona, where he settled and built a monastery. The success of his mission was phenomenal, and soon his efforts and those of his disciples were extended far and wide, reaching into England and to the Continent. Hearing of the esteem in which St. Mungo was held, "he desired to approach, visit, and behold him, and to come into his closer intimacy." The meeting of these two men and their attendants at the place called "Mel-

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* Macgregor Chalmers' "Saint Ninian's *Candida Casa.*"

† But see Skene's "Celtic Scotland," ii., 79.

lindenor" is graphically told in the life of St. Mungo. Each party was divided into three bands. In the front were placed the juniors, next the more advanced in years, then with the saints there walked those who had grown old in good days. On St. Mungo's side they sang, "In the ways of the Lord how great is the glory of the Lord," "The way of the just is made straight and the path of the saints is prepared." On St. Columba's side they responded, with tuneful voice, "The saints shall go from strength to strength; unto the God of gods every one of them shall appear in Zion."* The saints passed some days together, and before they parted they exchanged staves, in testimony of their mutual love in Christ. The staff which was given by St. Columba to St. Mungo was preserved in the church of St. Wilfrid at Ripon as an object of veneration so late as the Reformation.

The outline of St. Mungo's life may be omitted here. No biography should be better known amongst us, since our city arms publish it every day. It is to St. Mungo that we owe our great cathedral, although no fragment remains to us of the structure which he erected. But we have still St. Mungo's well, which stood in his time doubtless on the east of his humble church, although it is now enclosed by the great fabric reared in later times. We can still identify the spot where tradition says the saint deposited the dead body of Fregus, which he brought with him at the first, that he might take possession of the land by a grave. Then we had, but no longer have, St. Mungo's bell, and gone, too, is St. Mungo's tree, a titled earned in distant days, probably, by the last relic of the grove at which he settled.

It has been mentioned that no fragment of any structure of St. Mungo's time remains. What was erected, whether of wood or of stone, was doubtless in the manner of the Celtic Church, in which St. Mungo was educated, and of which he was so brilliant a disciple and apostle. The plan of the Celtic Church did not possess the individuality characteristic of the plan of the Roman Church as exhibited in the examples mentioned.

The very simplicity of the Celtic plan, since it consisted of an oblong chamber only, may perhaps indicate that the service in the Celtic Church was of the simplest character. There is one peculiarity, however, in the plan of these churches which has not

* "Ancient Lives of Scottish Saints," p. 264.

received the attention which it merits. The altar was placed at the east end of the church, but the orientation differed by several degrees from that of the Roman Church, at least of later times. Perhaps the most striking example of this peculiarity is to be seen at the little church of St. Mary on the Crag, or Kirkheugh at St. Andrews, of which, unfortunately, little more remains than the foundation. This church, as finally planned, was cruciform, with an oblong chancel, a nave, and north and south transepts. The nave and transepts were set off exactly parallel to the lines of the great cathedral, and of St. Regulus' Church in its immediate neighbourhood. The chancel, however, lies at an angle to all the other buildings, the angle representing three degrees further north. The inevitable conclusion is, it seems to me, that this small chancel marks the site of the ancient Celtic Church associated with St. Raigail, Regulus, or Rule, who was with St. Columba, near Sligo, in the year 573. All who have studied Dunblane Cathedral must have been struck with the fact that the tall square tower is not in line with the cathedral. The angle of its direction, in relation to the other parts of the building, which are of much later date, represents three degrees further north. As this tower was never designed to be connected to any building it may be considered as a late example, in a square form, of those independent round towers so closely identified with the Celtic Church. Its position to the south-west of what was doubtless the site of the ancient church corresponds exactly with the position of the round tower at Brechin. Many other examples of this peculiarity in orientation might be noted at Iona, Inchcolm, in the West Highlands, and in Ireland. The point merits more extended investigation.*

Although there is no actual evidence, it may be assumed that St. Mungo's Church was in form and direction in the manner of the Celtic Church. Whilst neither the direction nor the form has had any influence on the plan of his successors of the thirteenth century, the site has been a dominant factor in the production of their general design, for it is in the highest degree probable that it is to the position of this early structure we owe one of the most interesting and beautiful features in our cathedral. There appears to me to be no reason in suggesting even the bare possibility, as has been done, that our cathedral was not reared on

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* Macgregor Chalmers' "Saint Ninian's *Candida Casa.*"

the site of St. Mungo's Church.* Following the recognised custom, St. Mungo was in the habit of erecting stone crosses at those places where he had won the people to Christ. Two such crosses are specially referred to in the life written by Jocelin at the end of the twelfth century as existing at that time, and possessing the power to work miracles. One was cut by quarriers from a block of stone of extraordinary size, and, by many men and the use of machines, was set up at Glasgow in the cemetery of the Church of the Holy Trinity, in which his episcopal chair is placed.† The site was easily identified. We have good reason to regret the destruction of this cross, and of much that belonged to those early times. St. Acca's Cross and the many others preserved in the library of Durham Cathedral; the beautiful collections in the museums at Newcastle and St. Andrews, and in the cathedral there; the cross at Ruthwell, and many others throughout Scotland,—works of the utmost delicacy and beauty and of the greatest value—all indicate how great is our loss.

St. Mungo died about the year 601. In his biography it is recorded that in the cemetery of his church 665 saints rest, and all the great men of that region have long been wont to be buried there. The faith had not died out completely, and St. Mungo's Church was known.

From the time of St. Mungo's death to the founding of the see by the sainted Prince David in conformity with the church system so closely associated with the name of Saint Margaret, his mother, we plunge through centuries of darkness. So far as this district of Strathclyde is concerned, we learn only that, in the early part of the eighth century, Sedullius was bishop; and we have it on the authority of Bede that the people were induced to change from the Celtic and to adopt the Catholic observance of Easter through the influence of Adamnan, Abbot of Iona.‡ The Celtic Church met with a severe reverse towards the end of the seventh century. Through ignorance of changes which had been made by the Western Church, the Celtic Church retained the

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* Mr. John Honeyman has suggested that Govan might have been the right spot, since there are many early monuments in that churchyard. He made no attempt, however, to show that any of these monuments are of earlier date than the cathedral founded by King David.—Report Brit. Archæ. Assoc. Congress at Glasgow, 1888, p. 14.

† "Ancient Lives of the Scottish Saints," p. 269.

‡ Bede's "Ecclesiastical History," B.V., c. 15.

ancient usage in some matters, such as the time of keeping Easter. This fact was first brought to the knowledge of both Churches in the year 590, when intercourse was renewed by the arrival in Gaul of the Irish monk, Columbanus.* In the seventh century earnest efforts were made to secure conformity. In the year 634, Pope Honorius wrote to the Scots—that is, the Irish—"earnestly exhorting them not to think their small number, placed in the utmost borders of the earth, wiser than all the ancient and modern churches of Christ throughout the world; and not to celebrate a different Easter."† The matter was keenly fought. At the famous Synod of Whitby, in the year 664, the decision was against the Celtic Church.‡ It then lost its aggressive power.

One of the first tasks undertaken by Prince David in connection with the new foundation at Glasgow was to place on record a list of all the possessions of the ancient Church. This record is known as "THE INQUEST OF DAVID," and it is still preserved.

"He indeed (that is, Prince David), burning with zeal for holy living, pitying the wretchedness of the profane multitude, moved by divine promptings, in order to wipe out their reproach by that pastoral care which too long they had lacked, by the aid of his Nobles and Clergy, skilled in counsel, chose as Bishop, John, a certain religious man who had educated him, and had vowed, not without effect, that his life should be devoted to God. But when the Bishop learned of the savage state of that unhappy people, and of the abominable multiplicity of their vices, as one greatly terrified he had arranged to set out for Jerusalem; yet being consecrated, although against his will, by Pope Paschal, he would by no means put off assuming the duty of the charge he had undertaken, and being readily accepted by the people and welcomed by the Prince and Nobles of the Kingdom, he spread abroad the Gospel throughout the Cumbrian diocese, the Holy Ghost abundantly assisting him."§ A note of the property belonging to the Church is given at the end of the document.

Bishop John, the first bishop, was consecrated in the year 1115, and the church he erected was consecrated in 1136.|| This church must have been constructed of stone; it could not possibly have

* Skene's "Celtic Scotland," ii., 6.

† Bede's "Ecclesiastical History," B.II., c. 19.

‡ Skene's "Celtic Scotland," i., 259.

§ The Inquest of David, "Scots Lore," p. 38. Mr. J. T. T. Brown.

|| Regi. Epi. Glas., Pref., xx.

been of wood at this date, as is so frequently suggested, and its style of art must have been that known as Norman. Not a single fragment of this structure is now visible. It is natural to infer that the first work undertaken in connection with the erection of our great mediæval cathedrals was the preparation of a design of a completed structure. The necessity seems ever to have been present to the minds of the builders, however, to push forward the erection of the choir—the site of the high altar—so that divine worship might be offered up at the earliest moment. Careful examination of many examples shows that only in the rarest of cases was the erection of any other part than the choir undertaken at the outset. We cannot tell what was the nature of the work carried out by Bishop John. That it was the choir, and that only, may be held as certain. It may even have consisted of the centre aisle only of a small choir. The testimony of all the other fabrics of this date warrants the assumption that this choir terminated at the east end in a semi-circular apse.

Bishop John was succeeded by Bishop Herbert in 1147. We do not know—there is no evidence in MS. or in stone—that this bishop ever made any addition to the building. On his death, Bishop Ingelram came to the see in 1164. It is to this bishop, and not to his successor, that I attribute the erection of the earliest portion of the present existing building.* What remains is a mere fragment, consisting of nothing more than a foot or two of bench table, a single shaft with its unfinished capital and its base, and a few stones of walling. Several loose stones, still preserved in the chapter-house, have been part of the same work. This fragment of a building will be found at a spot a little more than 20 feet from the west end of the south aisle of the present lower church. There is no evidence to warrant the suggestion that the wall in which this pillar stands extended further south than the south face of the south wall of the existing structure. This fragment of wall is evidently a portion of the east wall of the original south aisle of the choir. The limit of the semicircular apse of the centre aisle is then approximately indicated by the existing shrine of Saint Mungo. The position of this early wall shaft which is still preserved marks, I believe, one of the angles of an apsidal termination to this south aisle, but apsidal only in the vaulting. The value of this suggestion will be more

* Mr. John Honeyman describes it as the work of Bishop Jocelin. Glas. Archæ. Soc. Transactions, 17th March, 1881.

apparent if it is kept in view that the south wall of this early date may have been thinner than the present existing wall.

In many structures the side aisles show an apsidal termination in the interior, whilst the square form is retained on the outside. The foundations of the ancient south aisle of the choir of Durham Cathedral, recently discovered, established the fact that it was designed on this plan.*

It is a matter for sincere regret that only so small a fragment of this original work remains. But the plan, although it is thus slightly indicated, is exactly what ought to have been anticipated—a short choir, with a semi-circular apse, and two very short aisles. The original builders never contemplated the magnificent shrine we now possess. It is important to note that in many particulars, and not least in that of size, this choir of Glasgow corresponds with the choir of Jedburgh Abbey, erected a few years earlier, and in Glasgow diocese.

Was the original choir of Glasgow of two storeys, or of one only? I am not aware that this question has ever been asked before. Yet it may be asked, and the answer will be doubtful. It must be answered on more sufficient evidence than the mere existence of two storeys now. If the original plan of the small choir included a lower church or crypt, the plan which was in general use for such structures becomes of the most vital importance. I do not believe that the side aisles of this lower church, if of the present width, or nearly so, were mere passages leading to the centre aisle, which was the repository of the sacred relics of the saint. These relics were doubtless preserved at the point still indicated by Saint Mungo's shrine, which we must suppose was placed immediately under the high altar in the choir above. As, from its plan, it is improbable that there was any altar in the centre aisle, the side aisles would then be used as chapels, with an altar in each against the east wall, for the service of the faithful who came to venerate the sacred relics. One of the churches whose design throws considerable light upon this early work at Glasgow is that of St. Avit de Orleans.† Whether the original foundation was of two storeys or of one, the nature of the work undertaken by Bishop Ingelram's successor shows that a choir of two storeys, existing or in prospect, influenced his design.

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* Greenwell's "Durham Cathedral," 5th edition.

† V. le Duc's "Dictionnaire Raisonne de l'Architecture," iv., 449.

Bishop Ingelram died in the year 1174, and Bishop Jocelin succeeded. He was consecrated on the 1st June, 1175.* We owe the present nave to Bishop Jocelin, which he began as an addition to the existing choir, but, unfortunately, only so far as the general plan is concerned, and the erection of the lower part of the outer walls, including the outer base course, the interior wall bench, the bases of the small shafts on the north and south walls, the west responds of the two transepts, and the more advanced north and south responds of the west wall.

To all students of art it must ever remain a matter of regret that Bishop Jocelin did not complete the great structure which he commenced. Although the later builders have been content to follow his plan—and the early character of the plan is a striking feature still—the fabric of later date which we possess lacks the charm of the work of the earlier period. The great Abbey of Arbroath, founded by King William the Lion, is a contemporary work, and there is much that is common in the two buildings. In both, the nave consists of eight bays, with two western towers in addition. One of the chief interests attaching to Bishop Jocelin's fragment of a projected nave, apart from the evidence of its date, is that the level of the floor is at a considerable height above the level of the floor of the present lower church. We have in this fact clear evidence that by this date a choir of two storeys had been determined upon.

Bishop Jocelin received a charter from King William the Lion in the year 1190, giving royal sanction to the collection of funds for the erection of the cathedral. In this charter reference is made to the recent destruction of the building by fire. We also know that the cathedral was again dedicated in the year 1197.† What is the evidence of the building? It is clear and distinct. Bishop Jocelin, after some years, perhaps, devoted to the construction of the nave, suddenly interrupted the work. The cause of this interruption we may now assume to have been the destruction referred to in the charter. As there was no completed nave, the part of the building destroyed was the already-existing choir. The bishop naturally turned his attention away from the work which could well be delayed, to the work of restoring the choir, which was necessary for divine service. It was this new work of restoration which was dedicated in 1197. It is expressly

* Regi. Epi. Glas., Pref., xxiv. † Regi. Epi. Glas., Pref., xxv.

stated in the charter that the church was constructed anew. That is the testimony afforded by the building, with this exception, that the bishop retained of the older work that most insignificant fragment, the old wall shaft already referred to. Bishop Jocelin's work at the very close of the twelfth century is now disclosed in that portion of the present south aisle of the lower church extending westward from the ancient wall shaft — which still marked the eastern limit of this south aisle—to and including the large piers at its western end. The south wall, with its outer base course, its interior bench table, the wall shafts, and the windows, are all of this period. Only a small portion of the north wall remains. Then the whole vaulting of this short aisle was executed at this time. It is important to observe that the wall shafts in the south wall, whilst of a later type than those in the nave, differ entirely from all the pillars or shafts in the later lower church, being of earlier date. The vaulting at this part springs at a level twelve inches higher than the rest of the vaulting in the lower church. It is to be noted also that the diagonal rib at the east end, which falls upon the capital of the more ancient wall shaft, falls upon it at haphazard, having no properly designed relation to it. I know that a great mystery has been made about what has been considered the almost miraculous preservation of this section of vaulting, the supposition being that no part of the walls under it are of the same date. The greater part of the walls and the vaulting are of the same date. They have never been disturbed. There is no mystery whatever.* But there is further evidence in this south aisle that works were executed there at the very end of the twelfth century. It has been asserted time and again that the carving on the capital of the ancient shaft in the east wall is of later date than the shaft itself. This is perfectly evident to all who are acquainted with Scots mediæval art. It is a singular fact, however, that the question has never been propounded—when was this carving executed? Yet once the question is put, the answer is not a matter of much difficulty. The carving is of the same date as this aisle now described; it belongs to the period when what is known as Transitional art was merging into that of the thirteenth century. This can be illus-

* Mr. John Honeyman erroneously supposes that the twelfth century aulting rests on walls "built not before the second quarter of the thirteenth century." Glas. Archæ. Soc. Transactions, 17th March, 1881.

trated by reference to any examples of this date—to the beautiful, late transitional eastern door of the cloister at Paisley Abbey, or to the carved capitals in Arbroath Abbey, which are so similar in design as almost to suggest that they were carved by the same hand that wrought at Glasgow. That the carving of the capital of this pillar was delayed need cause no surprise. The carving on the base and shaft of the pillar in the centre of the vestry in the cathedral is still unfinished.

During the course of some recent investigations I discovered the north wall of the north aisle of the choir erected by Bishop Jocelin.* The wall extends the same length as that on the south. Although a later building has been erected against this wall, to the north, the original splayed base is still in existence. All doubt is now at an end as to the outline of the choir aisles of this period. There is no evidence to show whether or not Bishop Jocelin retained the original line of the central apse, or whether he enlarged the choir and finished it with a square end. At the end of the twelfth century the cathedral consisted of a restored choir, comprising a lower and an upper church, with a nave and transepts, of which only the lower parts of the walls had been built.

Following the death of Bishop Jocelin in the year 1199, and before the coming of Bishop William de Bondington in 1233, there is an interesting period, the limit of one generation, which hitherto has been ignored. In Walter, who was chaplain to King William, and who was consecrated in 1208, Glasgow had a distinguished bishop. He occupied the see for twenty-four years. There is evidence that the building of the nave was again undertaken. The design of the piers of the main arcades is of this date. It is worthy of notice also that one of the most interesting and striking masons' marks found on the lower part of these piers is repeated on the piers in the lower church, executed some years later.

It is not recorded that Bishop Jocelin's choir was accidentally destroyed. I believe, rather, that so much of it as was necessary was deliberately removed in order that the present great choir might be carried out—a work whose magnificence is at once not only an indication of the good taste of the bishop and of the skill of his great architect, but of the surprising wealth of the diocese.

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* Glas. Archæ. Soc. Transactions, vol. iii., part i., p. 88.

The cult of St. Mungo had been fostered to good purpose when such a work as this was possible.

The choir is of five bays, with a structure added to the east end of more than ordinary interest. The loose manner in which names have been applied, and are still applied, to the several portions of our cathedral, is surprising. This feature at the east end, east of the high altar, has been called the Lady Chapel, as if the Chapel of Our Lady, had there been one, could possibly be of this form.* Nor is it a retro choir, as has been suggested. It is a chapel of four altars, and it is present in both the lower and the great church. Contemporary with this work in Glasgow are the Chapels of the Nine Altars at Fountains Abbey and at Durham Cathedral. A later work of the same character was erected at Hexham Abbey, although it has been removed within recent years. It is worthy of remark that at Glasgow and Durham the contemporary works were an eastern extension of an existing choir, and probably both works included the removal of a semicircular apse. In both cases the site of a famous shrine containing the relics of a saint was retained in its original place, and specially distinguished; and as the ground at both buildings sloped down towards the east, advantage was taken of this circumstance to lower the level of the floors in order to increase the apparent height of the structures. In Durham the Chapel of the Nine Altars is one of the greatest buildings of the mediæval period. It is carried to the height of the central vault of the choir. In Glasgow, on the other hand, the height is restricted to the level of the vaulting of the side aisles. It is an interesting fact that the Bishop of Glasgow sent a contribution in aid of the great work at Durham.

The present choir of Glasgow Cathedral was probably begun during the episcopate of William de Bondington—1233-58—and was completed about the end of the thirteenth century. As a work of art it ranks as one of the finest in the country.

Reference has already been made to a building which was erected to the north of the north aisle of the ancient choir. This building, of which only parts of the base course remain, was originally of two storeys in height. The evidence which is still available points to its having been erected in the thirteenth century. The opening from the lower church to the ground floor

* Report Brit. Archæ. Assoc. Congress at Glasgow, 1888, p. 10.

will be found cut through the ancient north wall. It is now roughly built up. The entrance to the upper floor was from the west bay of the north aisle of the choir. On the removal of this building some years ago, this doorway was carefully built up, but I have found sufficient evidence to make it clear that it was a doorway of considerable importance, and that probably it was richly ornamented. The greater part of the window in this western bay of the choir is modern. The low building to the north has been described as the Hall of the Vicars Choral.*

That the lower church in the cathedral was purposely and most skilfully designed to be used for divine worship as a church is evident if regard is paid to the beautiful lines upon which it is planned. The design of the centre aisle has worthily received the praise of every student of art. Neither in the disposition of the pillars, nor in the wonders of its richly-moulded vaulting, is it excelled by any work of mediæval times. The pillars have been disposed, in the first place, I believe, to allow a free passage of light from the aisle windows, and also to permit of the most extended view possible throughout the building. But it will be noticed, in addition, that the centre aisle is planned as three chapels. The one on the west and the one near the centre have a single pillar only, whilst that on the east is entirely free. This east chapel marks the site of the high altar in the great choir above. St. Mungo's shrine is beautifully indicated by the square formed by the four small pillars near the centre of this mid aisle. By this arrangement the designer marked the site of the high altar in the foundation of the time of Prince David, as that again doubtless marked the site of the altar in the little church erected by St. Mungo. Great interest was shown in preserving the sacred character of such spots. The eye of the great dome of St. Peter's at Rome looks down directly on the site of the altar of the ancient basilica, for ever vanished. The wonderful adaptability of this centre aisle at Glasgow is further illustrated if the western and centre chapels are combined, with the shrine of St. Mungo in the middle. In this way, with only two pillars intervening, a chapel is secured measuring about 70 feet by 30 feet. A careful examination of this lower church reveals that we owe it, in all the details of its plan and construction, to the designer of the whole

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* Archbishop Eyre's paper. Glas. Archæ. Soc. Transactions, vol. iii., part i., p. 77.

eastern arm of the cathedral. It is a homogeneous structure, completed in accordance with the original lines laid down.* It is the most valuable art treasure we possess in Scotland, yet it is so darkened and obscured by the miserable painted windows that no part of it can be studied but by the aid of artificial light. It was designed and decorated, however, to be seen in a clear, full light. Sculpture has been employed with a lavish hand. The carvings of the capitals of the pillars, the carbels carrying the vaulting ribs, and the bosses at the intersections of the ribs, form a wonderful gallery of sculpture of almost endless interest. Special attention may be directed to the bosses in the vaulting of the north aisle and under the high altar.

The carvings of the chapter-house door, at the north-east corner of the lower church, are also of great interest. On the western jamb there is a series of carvings which may symbolise "the perfection of the active life." It is unfortunate that decay has removed from the lower part all but the faintest suggestion of the human figure, and the symbolism is lost. The three upper panels, however, are nearly perfect. The figure at the top holds a book in the left hand, and the right hand is raised in the act of benediction; a nimbus surrounds the head. This may be "the apostle." The figure next in order is "the bishop." He is mitred, and holds his crosier in his left hand, whilst his right hand is raised in benediction. The third figure, and the last to be clearly deciphered, probably illustrates "the doctor," as he is shown reading from a large book of the law open before him. The Scots mediæval architect who illustrated the seven ages of man on the west front of the rood screen which he erected for Archbishop Blacader may have owed the suggestion to these carvings on the chapter-house door.† Other works of the thirteenth century will be found in the lower parts of the chapter-house, the landings at the western entrances to the lower church, and in the walls and pillars of the

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* A statement of Mr. T. L. Watson's theory that the original design of the vaulting, for which all the necessary preparations had been made in the springer stones, was abandoned, and a new design substituted, will be found in the *Transactions of the Philosophical Society*, vol. xxvii., p. 136. At a meeting of the Archæological Society (April, 1897) I showed that this theory is without foundation. It is also condemned in the preface to the third volume of *The Ecclesiastical Architecture of Scotland*, recently published.

† Macgregor Chalmers' "A Scots Mediæval Architect," p. 19.

low building which projects to the south of the south transept, and known as the "Isle of Car Fergus," a structure which was designed originally as the lower storey of a greatly-extended transept.*

Before passing from the lower church, reference may be made to some of the memorials of the dead which are still preserved. There are two sarcophagi at the west end of the lower church. These were originally sunk beneath the level of the floor, with only the stone lids exposed. Now they stand on the floor. The lid of one has been ornamented with a beautiful floriated cross of fourteenth century type, but this has now almost entirely disappeared. It is probable that a memorial brass adorned the other lid. A sculptured slab of the fifteenth century, which was recently found in the churchyard to the south of the nave, and the effigy lying at the east end of the lower church, complete the list of mediæval memorials. It is almost certain that further discoveries will be made. There can be no doubt that there were relics in abundance. But in a rapidly-increasing centre like Glasgow, it is not surprising that early memorials have been lost sight of in making way for those of later times. In quiet spots, such as Govan was until recently, it is natural that many early sculptured stones should be preserved. The curious hog-backed stones there, the crosses, and the wonderful sarcophagus, are of great interest. If the sarcophagi at Glasgow are compared with that at Govan, it is natural to conclude that it enclosed relics peculiarly venerated. My scale drawings of this sarcophagus were published some years ago in the first volume of the Glasgow Regality Club. It is to be noted that many interesting relics of the past are still preserved at Inchinnan, although at Paisley, as in Glasgow, they have been overlaid or destroyed.

The recent history of the effigy of a bishop, which now lies in the chapel of the four altars of the lower church, has a peculiar interest. When the cathedral was restored to some decency and order about fifty years ago, this effigy was removed from its present position, and was placed on the floor, within the four pillars which mark Saint Mungo's shrine. It was then christened "The effigy of Bishop Joceline." Thus was error added to error. The head of the effigy, which had been preserved until this time,

* This has always been described by Mr. John Honeyman as a copy of 13th century work executed at the beginning of the 16th century. Report Brit. Archæ. Assoc. Congress, p. 12.

has now disappeared. This effigy was at one time the subject of discussion. No one, however, seems to have noted that the feet had been broken off, in order that the stone might be made to fit the space in which it lies. In this there was clear evidence to connect the effigy, in the end at least, with its present site. That a burial had actually taken place here is also clear, since the tomb was wantonly broken into some years ago, and the relics found there stolen. It was on no such ground that the effigy was returned to its place. It was returned, and a new name was given to it, by reason of a mere conjecture, founded upon a statement made by M'Ure, who wrote 400 years after the event to which he referred, and the source of whose information is still undetermined. His reference, at the time, might have been as wisely considered to apply to any part of the cathedral.* The history of this effigy has yet to be made known.

There is perhaps no story of our cathedral which possesses greater interest than that related of Bishop Wischart and his bell tower. No document in connection with the cathedral is better known than that which records, in the year 1277, the granting of timber from Luss for the erection of a "*campanile et thesauraria.*"† Nor is any incident, perhaps, more characteristic of the patriotic bishop than that complained of by King Edward I. of England, that timber which had been granted in the year 1291 for the building of the bell tower (*clocher*) to the cathedral had been used by him in constructing engines of war against the king's castles, and especially the castle of "Kirkintolach."‡ The tower of the cathedral was wrecked at the beginning of the fifteenth century, and an early effort was made to restore it.§ As the parapet of the present central tower bears the arms of Bishop Lauder, who was bishop early in the fifteenth century, it has been assumed that the bell tower, which was in process of erection at the end of the thirteenth century, and which was destroyed, was this central tower. Following from this assumption, in seemingly the most natural order, the nave has always been described as having been completed in the thirteenth century.‖

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* John Honeyman's "The Age of Glasgow Cathedral," p. 18.

† Reg. Epi. Glas., No. 229, pp. 191, 192.

‡ Reg. Epi. Glas., Pref., xxxvi.

§ Reg. Epi. Glas., Pref., xl.

‖ John Honeyman. Report Brit. Archæ. Assoc. Congress, Glasgow, 1888, p. 12.

As there is no evidence of any destruction and repair at the crossing under the central tower, I was led to search for evidence which might, perhaps, connect these records of a tower with the north-western tower, unfortunately destroyed about 50 years ago. According to the records, two buildings were in process of erection at the end of the thirteenth century—a bell tower and a treasury. Two buildings bearing those very names existed at the west front of the nave until 50 years ago. The building at the north-west corner was the bell tower. All the drawings of these structures show that, in their lower stages, they were of thirteenth century workmanship, and the evidence that work of this date was executed at this point is still, happily, present in the great western doorway. The drawings of the bell tower show that it was built in two different styles—the evidence of different dates. The lower part—about one-third of the height—had deep projecting buttresses. The upper part was square and plain. There was a stone vault in the interior at the level of the junction of these two sections of work. The moulded ribs, where they sprang from the four angles of the tower, were supported on corbels carved with human figures. By the rarest good fortune, three of those four corbels are now preserved in the chapter-house. They are of early fifteenth century design. A detached north-western tower, erected at the end of the thirteenth century, has no direct bearing on the date of the nave. The evidence on that point must be found within the nave itself.

It has been no part of my present purpose to give a complete sketch of the history of the cathedral. That is a great task. The moment has appeared to me as opportune for creating a fresher interest in the building by throwing what I believe to be a clearer light upon several points which have been darkened by the opinions at present held and expressed. The truth will be found to be that which is most practical, and most in accordance with the orderly action of the human mind, and, let me add, the most fascinating, since it will vibrate with the touch of human emotion.

XV.—*Observations on the Aerial Transmission of the Enteric Fever Poison, with a Record of an Outbreak presumably caused by that means of infection.* By John Brownlee, M.A., M.D., D.P.H., Pupil Assistant, Glasgow Sanitary Office.

[Read before the Society, 6th April, 1898.]

There are few problems which have so often seemed near solution, but of which the solution has been found on examination to be incomplete, as the nature of the means by which enteric fever is spread. The research has been carried on by two different methods, roughly divided into two periods by the year 1880, which marks the discovery of the bacillus by Eberth. Before that date the investigation was confined to the observation of the conditions and circumstances under which enteric fever arose, spread, and diminished, and there was a general consensus of opinion that the presence of putrefying filth, which infected either directly or by means of the pollution of water or milk, was essential to its production. But opinions were divided as to whether filth of itself could acquire the specific property which engendered the disease, or whether the addition of some definite infective material was necessary to render it dangerous. All this now is but the echo of the famous controversy on spontaneous generation. This doubt was finally, though not immediately, set at rest by the discovery of the enteric bacillus. But the new discovery brought new difficulties. Laboratory experiment decided the life of the organism to be precarious, that there could be no doubt that it might live in water for a short time, say, about a fortnight, but that it speedily disappears, and does not multiply; that mixed with other organisms it quickly perishes in the race for existence. It was supposed that it could not be recovered from infected soil, nor even from the sewage of a fever hospital, into the drains of which the discharges of enteric fever patients had been thrown without disinfection. In fact, the result of all the experiments seemed to show that it was a wonder

that the bacillus had not long since disappeared from the earth. Within the last two years the great facts, which were the basis of the former theories, have recurred so often and made themselves so prominent, that reinvestigations of the characteristics of the micro-organism have been made under a new variety of conditions. These experiments have been rendered much more easy by the discovery of new means of isolating and identifying the organism.

To begin with, I shall give a brief account of what has been done by the various observers, and thereafter discuss the general state of knowledge of the subject at the present time.

It has been found, in the first place, that if ordinary arable land be infected with the bacillus, the latter can show a prolonged vitality. Dr. Robertson,* Medical Officer of Health for Sheffield, has recently published an account of some interesting experiments begun in July, 1895. He had the turf carefully removed from the surface of several patches of an ordinary grass field. These patches of ground were watered with broth cultures of the enteric bacillus diluted in water, in one on the surface, in another at nine inches depth, and in a third at 18 inches depth. In the latter cases the soil was first removed to the depth mentioned in the order of its stratification, and then carefully replaced. During the autumn, 130 days later, he found on examination, not only that the bacilli which were sown on the surface had multiplied, but even that those which were sown 18 inches beneath the surface had so proliferated that the bacillus could now be found in the surface layer of the soil. Again, he found during the cold months of winter that from these and other patches of ground which had been similarly treated in the autumn no enteric bacilli were recoverable. During the spring some of the patches were watered with very dilute sterile broth, to imitate in a measure the continuous contamination of the soil which may be supposed to take place in certain localities by sewage. It was found that from those which were so treated the bacillus could in June be recovered with ease, but none at all could be obtained from the patches which were not so treated with dilute broth. It would thus seem that, though apparently absent in the cold of winter, the bacilli might be nursed back in the warmer weather to an active existence if

* *British Medical Journal,* January 8, 1898.

the means of subsistence were supplied. It would have added interest to the experiment if those patches of soil in which the bacilli were not detected in June had then been watered with broth, as the others were, to discover whether, even after that longer interval of time, a further growth of the bacilli could have then been induced.

In association with these must be narrated the experiments of Dr. Sidney Martin.* In those, however, the natural conditions were not imitated so closely as in those of Dr. Robertson, and they are therefore not so conclusive. Dr. Martin obtained numerous specimens of soil, some from sources grossly polluted, contaminated with organic matter from localities in which enteric fever was endemic. Besides these he procured specimens of virgin soil from the downs of Hampshire. These were chosen from the deeper layers which underlie the surface peat, and consist of a mixture of sand and completely decayed vegetable matter. Part of each of these samples was pulverised, placed in an Erlanmayer's flask, moistened, and then sterilised. It was found that the growth of the bacillus was rapid and luxuriant in the polluted earth, especially at higher temperatures, 90° to 100° Fahr., and though much slower at the temperature of the room, that even then it took place. In these flasks the bacilli were still active after the lapse of 105 days, the duration of the experiment at the time the results were published. With regard to the virgin earth a much different result appeared. Not only did proliferation not take place, but even after a time the living bacillus could not be obtained at all. It seemed completely killed out.

It would seem, then, that these two observers agree in their opinion that, given suitable conditions, the bacilli of enteric fever may retain its vitality in the soil for a lengthened period. But what are those suitable conditions? Sewage as a suitable medium for the growth of the bacillus had been set aside by former observers, and a repetition of the experiments on this point by Dr Klein† resulted in their confirmation. But this observer, in view of the changes which occur in the natural purification of sewage, of which the most notable is the formation of nitrates by oxidation, tried whether the artificial addition of these salts to crude sewage would produce a more suitable medium. He

* Local Government Board Reports, 1896-97.

† Local Government Board Reports, 1894-95.

discovered that the bacillus does not die out rapidly, as was observed in former experiments, but grows luxuriantly, the addition of nitrates converting the sewage from an unsuitable medium into one very favourable to their growth.

In another series of experiments he found that if the bacillus were added to certain of the London drinking waters it could be found after the lapse of five to eight weeks, and in certain lake waters even longer. This is a much longer period than had been thought of. Frankland found that in Loch Katrine water, which was apparently exceptionally favourable, the duration of life was but 25 days. The results of these experiments apparently show that, while the pollution of water directly by sewage might not be of serious moment for more than a short time, yet if the character of the medium intervening between the source of pollution and the point at which the water is taken for use be of such a nature as will admit of the ready formation of nitrates, on which the growth of the bacillus seems largely to depend, then the specific contamination may continue for a lengthened period of time.

There are other points, however, in the condition of its life. Some media which are unsuitable for the growth of the enteric bacilli can be made suitable by the action of other micro-organisms; for instance, as has been noticed already, the action of the nitrifying bacilli make sewage a suitable medium. Pure gelatine is not a suitable culture medium, yet in some experiments made by myself it was found that if liquefied by certain other micro-organisms the resulting fluid was most suitable. This, however, was not a constant result with different species of liquefying organisms. In a few other experiments, made with a view to ascertaining where the typhoid bacillus can maintain itself under natural conditions, several specimens of soil were chosen. These consisted of peat which had overgrown a rocky patch in an open moor, and beyond suspicion of contamination by manure and sewage, decayed leaves from a wood, and the detritus from the face of a weathered trap rock. These samples of earth matter were extracted with water. The resulting fluids were placed in tubes and sterilised in the usual manner, and then inoculated with the enteric bacillus. It was found that in the extracts from the peat and the leaves the bacilli had disappeared after ten days, while they grew abundantly in the extract prepared from the weathered rock. This result was probably due

to the fact that the detritus was gathered from a locality which was exposed, to a slight extent, to surface water from a manured field. The medium composed of decayed vegetable matter only did not afford anything like so suitable a medium as that contaminated by even a trace of animal organic matter.

I have already referred to the spread of enteric fever by polluted water or milk, but there is in addition another possible means of infection—namely, the aerial dispersion of the organisms. The most natural means, the dispersion of soil, is in the form of dust, when it is easily carried about by the wind. It is well known that the bacillus of enteric fever does not readily survive complete desiccation. The limit of the duration of its life in this state, Flügge, from his own experiments, in which the bacilli were dried in thin layers, has given at five to fifteen days. By Germano,* in a paper published last August, no certain limit is given, as in his opinion this limit depends on the amount of drying to which the bacilli are subjected. Half dried they lived for some months, wholly dried for but a short time. He found that on garments of wool the infection lingered longer than on those of cotton, a fact which he explains by the greater power the former has of retaining moisture. Now, ordinary soils possess the property of retaining in their interstices a certain proportion of moisture, and do not yield this to the ordinary natural means of drying, such as currents of air. In a few experiments made by myself in this connection, ordinary potting soil was placed in a porcelain dish, and thoroughly dried in a hot air steriliser. It was further subjected to continuous dry heat long enough to kill any micro-organisms present. This soil was then moistened with a broth culture of the enteric bacillus. By this means it was practically assured that the minute passages of the soil, filled by the action of capillarity with the broth, would at the same time be mechanically charged with enteric bacilli to the extent that where there was moisture there would also be the micro-organisms. This porcelain dish was then covered with a glass lid, the whole kept at 98° F. for 24 hours, after which the cover was removed and spontaneous evaporation allowed to take place. In the course of a week this soil had become dry enough to be easily scattered by the breath. It had become, in fact, dust such as can be readily blown about

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* *Zeitschrift für Hygiene,* XXIV., 3.

by the wind. As it might be assumed with certainty that the soil with which the experiment was conducted had become contaminated by micro-organisms derived from the surrounding air, it was now saturated with meat broth, to which a little carbolic acid had been added, the presence of the latter restricting the growth of those other micro-organisms while allowing the free growth of the enteric bacillus. Plates of Elsner's potato gelatine were made from the earth so treated, and a bacillus recovered which agreed in its more important characteristics, microscopical and others, with the enteric bacillus. A similar experiment was made with unsterilised soil, but the colonies of the bacillus *coli communis* were so numerous that it was found impossible to separate the enteric bacillus from these, owing to the close resemblance in character of the two organisms. This experiment was undertaken solely with a view to decide whether the aerial transmission of the bacillus be possible, and was consequently carried out under conditions which favoured that micro-organism as much as possible. The fact that an active bacillus was recovered after almost complete drying, when the soil was in a condition capable of being carried about by the wind, indicates at least the possibility of aerial transmission. The extent to which this takes place can only be decided by an appeal to natural processes and not in the laboratory.

Having thus briefly explained the present state of experimental knowledge regarding the enteric bacillus, before passing to an account of the outbreak, of which the present paper is a record, I would wish to make a few remarks concerning the conditions under which the enteric microbe conducts itself in nature's laboratory, or in other words, the manner in which enteric fever rises, spreads, and disappears. A seasonal undulation has been found to exist showing a maximum and minimum range. Not only in endemic prevalence of this fever, but also in the occurrence of the epidemic form of the disease, due to pollution of water and milk, this is well marked. Of 200 water-born epidemics of enteric described by Mr. Hart, 40 per cent. began in the months of July, August, or September. This, however, is of interest only as a rough approximation. But if we consider the more accurate means of information provided by the number of notifications per month in different centres of population, more definite results may be arrived at. It is found, for example, that

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in Glasgow the second and third weeks of August may be counted upon to produce from 80 to 100 new cases of enteric fever. This rate increases through the whole of September, and then begins to decline. But the decline is much slower than the rise. If the winter be mild, the minimum may not be reached till the beginning of April of the following year. On the other hand, with a cold and frosty winter it may be reached by the end of January. Further, a cold spring and summer may delay the onset of the fever till a later period in the autumn. In London, on the other hand, where the summer is warmer and the winter colder, we have a somewhat different state of affairs. The numbers by notification begin to increase earlier in the year (July), and continue to increase till the month of October, after which the fall is rapid. The colder winter seems to ensure that the spring will be free from the disease, both absolutely and also relatively to Glasgow. In India, in the province of Bengal, we find enteric fever most prevalent during the hottest season of the year (May, June, and July). From these facts it would seem that the virulence of the organism producing the fever is cumulative, or, in other words, is built up gradually. This maximum of virulence, once reached, is apparently retained for a considerable period, and diminishes slowly. It may be destroyed by cold, as is indicated by Dr. Robertson's experiments before referred to. It may, in the absence of severe cold, last even through the winter, but the decrease once initiated is arrested only after a considerable time, even although the surroundings appear favourable. Conditions favourable to the organism may, however, exist even in winter, resulting in great epidemics. If the bacillus exist in filth, especially under snow, a sudden thaw and flood washing the filth into a water supply may cause a deadly epidemic. Organic filth is a fermentable substance, and can maintain a comparatively high temperature for a considerable time after that of its surroundings has fallen even below freezing point. A non-conductor such as snow would probably favour this, and a condition is thus produced which may be presumed to aid the growth of the bacillus. It was under such a condition the great epidemic in the Tees valley, in Darlington and Middlesborough, in the winter of 1890-91, and also the recent outbreak at King's Lynn, took place. In both cases much accumulated filth was washed into the sources of drinking water by heavy floods, and in both an epidemic was produced at a season of the year at which it is not usually

looked for. It might be argued, however, that a disease which is due to infection of the digestive track may have an early autumnal seasonal prevalence from causes other than the more potent properties of the bacillus. This season also coincides with a large increase in diarrhœal disorders from the dietetic changes corresponding to it. But the fact that food epidemics, such as those due to pollution of milk, spread with equal virulence, whether they occur in winter, spring, or autumn (the most severe of such epidemics in Glasgow was at the end of April), shows that it is the bacillus which requires for its potency a favourable environment, and, that granted such, there is no need for its host to be enervated by summer heat or predisposed by seasonal unsuitability of food.

From the fact already stated, that the virulence of the enteric bacillus is so slowly lost, we are led to infer what is a matter of general experience, that an epidemic of typhoid fever in a filthy locality, albeit sudden in onset, has a slow wane. The typhoid bacillus having found a resting place, has, it is true, a number to its days if suitable nourishment be not supplied to it, but it, unfortunately, only too often happens that the same carelessness which gives it a foothold also affords it a continual supply of nourishment. As an instance of this longevity of the bacillus may be mentioned a curious incident in an epidemic at Coalville, Packington, in Leicestershire. One well which had been instrumental in the spread of the disease was reopened thirteen weeks after it had been closed. The locking up of this well was followed by an immediate cessation of new cases, while the reopening of the well was followed by a fresh outbreak.

Further evidence, pointing in the same direction, is given by Dr. Child,* in a paper dealing with the history of enteric fever in Munich. This city, which is now almost ideally free from the fever, was formerly one of the plague spots in Europe. Of every 100,000 of its inhabitants, between 200 and 300 died every year from typhoid fever. This number of deaths probably represents ten times the number of cases, for in towns where the fever is endemic the victims are largely children, and the mortality consequently low. The conditions which favoured this prevalence in Munich were the following:—

The city is built upon a mixed surface soil, beneath which is a

* "Transactions of the Epidemiological Society," 1897-98.

bed of gravel of varying depths, which in its turn rests on a bed of impervious marl. Through this gravel bed filters a constant horizontal stream of water, which flows parallel to the river Iser and beneath the city. This underground water was conveniently used both to get rid of the sewage and also as the source of the water supply. Cesspools which were loosely constructed received the drainage; the water for domestic use was obtained from shallow wells. The slaughter-houses, of which there were a great number in the city at one time, had no other drainage. The more fluid refuse from these was likewise constantly allowed to pollute this source of water supply. Improvements were gradually introduced. The cesspools were rendered water-tight, and this alone was followed by a decrease in the enteric death-rate. A better water supply was introduced; and lastly, the slaughter-houses were all abolished in the year 1878. This last act was followed by a great and noticeable decrease in the number of deaths from enteric fever. This sudden improvement is rendered more interesting when we remember that *serum albumen*, such as must have constituted a fair proportion of the soakage from the slaughter-houses, is one of the most suitable nourishing media for many disease-producing organisms. The general conclusions arrived at by Dr. Child are as follows:—(1) The drinking water has not played an important part in producing and reducing the typhoid epidemics of Munich. (2) The great prevalence of typhoid in Munich was due to the great pollution of the soil (including specific pollution), modified by certain unknown conditions in the soil which are correlated with the movements of the subsoil water. (3) The gradual reduction of the typhoid was due to the gradual purification of the soil, and the almost abrupt termination of the epidemics to the sudden removal of all the slaughter-houses. He further suggests that the character of the soil may be a very important factor in the production of an epidemic.

The conclusion that the drinking water, under certain circumstances, has little to do with the endemic nature of the fever has a great interest. Much the same conclusion has been arrived at by Dr. Bulstrode* regarding the prevalence of enteric fever in Chichester, which has geological conditions almost exactly the same as those of Munich, and which had a like regard for con-

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venience and disregard for sanitation. In both these towns the fever seems to have attacked about equally those who drank pure and impure water. Of course, we must very much hesitate to accept this conclusion without question, for from the inter-association of people there is naturally a great deal of difficulty in absolutely deciding that a given individual has not drunk the contaminated water.

But even with an irreproachable water supply, contaminated soil alone may give rise to the continued presence of enteric fever. In the burgh of Rutherglen,* for instance, for a number of years, in the older part of the town, there has been a notable disregard for modern sanitation, no water closets, untrapped sinks, ashpits below the level of soil, with drop privies, and unpaved back courts being the rule. Yet, notwithstanding, there was no undue prevalence of enteric fever prior to the year 1894. During the autumn of that year a dairy in the district became a centre of infection, and certain of these streets in this part of the town were invaded. Since then enteric fever has been constantly present.

During 1895 the attack rate in this part of the town was ten times, during 1896 three times, and during 1897 four times that of the rest of the burgh. Specific soil pollution seems the only probable source of the infection. For it is to be noted that other streets, differing in no respect from these in point of sanitation except as regarding the absence of primary infection, have not been so attacked.†

The conditions for continuous soil pollution are here seen at their best. For as enteric fever is a disease of gradual onset, there is little doubt that each new case as it occurs will lead to the deposition of infected matter in the ashpits, which ceases only when the illness has become severe enough to demand

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medical attendance. The refuse from these ashpits is first emptied out into the street and thence removed. This method of removal produces fouling of the street; a certain amount of refuse, being left behind, is converted into dust and scattered about by the wind. We have but to look upon a basin of milk which has stood uncovered for a single night to see how much dust is deposited from the atmosphere, and if that dust be specifically polluted, there is no end to the vicious circle which keeps up both the supply of the poison and its distribution. That this is not purely theoretical is seen from the fact that Professor Delepine,* of Manchester, has obtained the enteric bacillus from the soil lying between the bricks forming the floor of an ashpit. In this case the contamination had taken place at least two months previously, and probably as far back as thirteen months. Either period, however, allows sufficient margin for the spread of the fever by the means under discussion.

The following series of cases which occurred in the City of Glasgow Fever Hospital, Kennedy Street, will furnish a clear example of the manner in which soil may be the means of aiding the spread of the fever. This hospital consists, as may be seen from the diagram, of seven pavilions of two wards each. The three northern pavilions, with the nurses' home, are new, and have a separate drainage system which discharges into North Oswald Street, while the drains of the southern wards, together with those of the kitchens and administration block, discharge into the main sewer in Kennedy Street. The ramifications of the drains will be appreciated more easily by a glance at the plan

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would seem to show that the infection was indirect—*i.e.*, from the soil, and not from patient to patient.

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than by any description. The whole drainage system of the northern wards was constructed about four years ago, and when tested after the outbreak was found in almost perfect order. With regard to that of the southern and older wards, it may be stated that when the hospital was re-opened a few years ago it was thought sufficient to renew the fittings in more immediate connection with the wards alone. The water closets, baths, traps, and ventilating shafts were renewed, but it was not thought necessary to relay the deeper part of the drainage system, it being considered at the time that the necessity for the hospital would be but temporary.

Owing to the absence of a grease trap the main effluent drain from the southern wards became gradually choked, till ultimately no flow of sewage was possible along the pipes. Under the resulting pressure the lutings of the pipes gave way and free leakage ensued. As a result, subsidence of the soil, which was of a porous nature, occurred, so that intermittent saturation of the subsoil with sewage was possible. The porosity of this subsoil, which was composed largely of furnace ashes, cinders, pottery rubbish, &c., while undoubtedly of great advantage in affording special facilities for natural purification, yet, according to the paper by Dr. Klein already referred to, would seem in this case to have rendered possible a prolonged existence of the enteric bacillus. The defects of the drains were discovered early in April, and their reconstruction was immediately entered upon. In the ordinary course of events this would probably not have had any serious effect, but in this instance several enteric patients had been inmates of the hospital, and their discharges were passed into the defective drains. These patients had been certified as scarlatina, but on admission no evidence of this disease could be discovered, and further observation showed them to be suffering from enteric fever. The first, a child of three, was admitted on December 31st, 1896, and by the time the nature of the case was sufficiently defined she was too ill to remove to Belvidere. This child was convalescent by the end of January. The second was a girl of fourteen years of age, who was admitted on January 12th, 1897, and transferred to Belvidere on January 14th, while the third took ill on February 19th, was recognised as enteric fever on February 26th, and transferred next day. Thus from December 31st till February 27th there was a more or less constant stream of infected dejecta passing

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* *Public Health,* February, 1898.

than by any description. The whole drainage system of the northern wards was constructed about four years ago, and when tested after the outbreak was found in almost perfect order. With regard to that of the southern and older wards, it may be stated that when the hospital was re-opened a few years ago it was thought sufficient to renew the fittings in more immediate connection with the wards alone. The water closets, baths, traps, and ventilating shafts were renewed, but it was not thought necessary to relay the deeper part of the drainage system, it being considered at the time that the necessity for the hospital would be but temporary.

Owing to the absence of a grease trap the main effluent drain from the southern wards became gradually choked, till ultimately no flow of sewage was possible along the pipes. Under the resulting pressure the lutings of the pipes gave way and free leakage ensued. As a result, subsidence of the soil, which was of a porous nature, occurred, so that intermittent saturation of the subsoil with sewage was possible. The porosity of this subsoil, which was composed largely of furnace ashes, cinders, pottery rubbish, &c., while undoubtedly of great advantage in affording special facilities for natural purification, yet, according to the paper by Dr. Klein already referred to, would seem in this case to have rendered possible a prolonged existence of the enteric bacillus. The defects of the drains were discovered early in April, and their reconstruction was immediately entered upon. In the ordinary course of events this would probably not have had any serious effect, but in this instance several enteric patients had been inmates of the hospital, and their discharges were passed into the defective drains. These patients had been certified as scarlatina, but on admission no evidence of this disease could be discovered, and further observation showed them to be suffering from enteric fever. The first, a child of three, was admitted on December 31st, 1896, and by the time the nature of the case was sufficiently defined she was too ill to remove to Belvidere. This child was convalescent by the end of January. The second was a girl of fourteen years of age, who was admitted on January 12th, 1897, and transferred to Belvidere on January 14th, while the third took ill on February 19th, was recognised as enteric fever on February 26th, and transferred next day. Thus from December 31st till February 27th there was a more or less constant stream of infected dejecta passing

into the drains. Of course, the ordinary means were taken to disinfect the discharges, but it is well known that these, however thoroughly applied, are of doubtful efficiency. All these patients were in the same ward, viz., Ward III. (the observation ward), whither they were sent on admission, and where they remained till dismissal from the hospital. It will thus be seen that the southern drainage system alone was specifically infected.

From this time there was no other case of enteric fever in the hospital till the indigenous cases occurred. Repairs of the drains were begun at the main effluent sewer about April 10th, and the obstruction removed. On May 6th a patient in Ward VIII. (southern section) had an evening rise of temperature, which was the first indication of what subsequently proved to be an attack of enteric fever. This patient was a boy of nine years of age, who had been five weeks in the hospital, and who (owing to scarlatina complications) had never been out of bed. On the fifth day from the rise of temperature just referred to the diagnosis was fairly certain. Owing to the drains being exposed lower down, great care was taken in disinfecting his dejecta. These were thoroughly mixed with crude carbolic acid, and allowed to stand a considerable time before being put into the drains.

On the suspicion of enteric fever arising, plate cultivations were made from the soil at the part where the men were at that time at work (marked *b* on the plan). The earth examined was taken from a part some inches above the level of the drain, so that the possibility of contamination from the motions of this last case might be as far as possible avoided. From this soil a micro-organism was obtained which, in several of the most important features, completely agreed with the typhoid bacillus.* Cultivations were also made from the soil midway between the surface and the drain (*i.e.*, about 2½ feet below the surface), with negative result as regards the typhoid bacillus. Search for the same bacillus was now made in some of the soil, thrown up in the process of excavation, which had dried in the sun. Though in laboratory experiments the enteric bacillus is easily killed by drying, yet dust, as already stated, even on the hottest day, con-

* Characteristic growth on agar and potato: non-formation of bubbles in a gelatine stab culture: Widal reaction.

tains a certain amount of moisture. Plates were made with Elsner's potato gelatine, and an actively mobile non-liquefying bacillus obtained, which in a gelatine stab culture formed no gas bubbles, and which gave a characteristic growth on an agar streak culture. Unfortunately, when the further investigation of the properties of the bacillus was resumed, it was found that the culture had lost its vitality. This bacillus, which was probably the enteric bacillus, was recovered from soil which could not have been contaminated by the dejecta of the case then in hospital.

Cultivations were also attempted on gelatine plates with the grease from the choked drain, but no organism resembling the bacillus *coli communis* or the enteric bacillus could be found.

From May 6th, when the first patient exhibited signs of enteric fever, till June 30th no further cases occurred, then they followed in quick succession, as will be seen by a reference to the accompanying table:—

TABLE OF ALL THE INDIGENOUS CASES IN HOSPITAL.

	Sex.	Age.	Admitted.	Showed first signs.	Ward.
J.C.,	M.,	9,	April 2nd,	May 6th,	VIII.
P.H.,	F.,	2,	May 7th,	June 30th,	I.
S.M.,	F.,	22,	May 16th,	July 1st,	XIV.
J.K.,	F.,	7,	June 29th,	July 14th,	IV.
H.W.,	M.,	10,	July 9th,	July 21st,	XII.

Clinically the features in each case were those of mild enteric fever, except P.H., in the case of whom the symptoms were somewhat anomalous. At the onset these were of a severe type, but subsided rapidly. She, however, gave a most typical Widal reaction. The circumstances which preceded the first case of enteric have already been detailed, and I shall now proceed to explain the further repairs carried out upon the drainage system at the various periods during the continuance of the enteric cases in the hospital. That portion of the drains below *a* and *b* (see plan) was the first portion taken up and relaid, and immediately thereafter the drain connections between this and the laundry, kitchen, and administration block were renewed. This work occupied the whole of May, and by the second week of June further work was commenced on that portion of the main drain marked *b* to *c* (see plan), which, as will be seen, was exposed both

to contamination from the original imported cases as well as of the first indigenous case. Two patients were now attacked by the disease, a young woman and a child. Two and three weeks later respectively two other cases of enteric fever occurred in the hospital. Those patients were both children, aged seven and ten, who had been strictly confined to bed from the day of admission. Both were mild but very characteristic cases of enteric fever. Of these cases two were resident in the northern and two in the southern portion of the hospital.

Outbreaks of enteric fever are usually associated with cases of slight febrile derangement, which cannot be definitely diagnosed as enteric fever. A resident physician and a nurse were thus affected.

So far as could be judged from the history of the patients and their environment before admission to hospital, there was no reason to suppose that any of them were incubating enteric fever on admission, and this opinion was further borne out by the length of time which elapsed in nearly all the cases between date of admission and the first onset of symptoms (see table). With regard to sources of infection within the hospital precincts itself, these fall to be considered.

(1) The milk supply. This was the same as that of the City of Glasgow Fever and Small-pox Hospitals, Belvidere, where no indigenous cases of enteric fever occurred at this time.

(2) Defective drains and traps connected with two infected wards. This source of infection is rendered very unlikely from the facts (*a*) that careful smoke testing revealed no practical defects in the traps or soil pipes connected with the wards; (*b*) that wards connected with both southern and northern drainage systems were infected, although, as already explained, the northern system of drainage was not in any way contaminated by the infected discharges from patients till the time when the first case occurred in Ward XII.; (*c*) the enteric poison (when we remember the date of admission of the first enteric case) was present in the drains of the southern section four months before the occurrence of the first indigenous case.

(3) The soil turned up during the repairs carried out on the drains. (*a*) The first indigenous case occurred in hospital about three weeks after the upturning of the soil when repairs were undertaken on that portion of the main drains marked *a-b*, while the second group of cases occurred from three to five weeks after

that, the portion marked *b-c* was taken up; (*b*) the sudden cessation of the indigenous infection as soon as the repairs to the main drains were completed; (*c*) the two cases which arose in the northern section of the hospital must have occurred as the result of some form of aerial infection, in view of the fact that the northern and southern drainage systems had no communication with each other; (*d*) that this source of infection was possible, and even highly probable, is manifest from the fact that micro-organisms presenting most of the characteristics of the enteric bacillus were procured from the upturned soil, which, owing to the warmth of the weather at the time, became rapidly dry, and so was readily carried about by the wind.

That this outbreak was most probably the result of infection present within the hospital precincts is shown by the manner in which it died out, as already described, when at the same time an outbreak of enteric fever present in the city was increasing steadily in extent and severity.

The proximity of the kitchen and stores to the turned-up soil during the repairs carried out on the drainage system makes it at least possible that the patients were infected by the food, which had in the first instance been contaminated by dust containing the specific organism.

As regards, then, the aerial spread of enteric fever, the conclusions which are of importance are as follows:—

Firstly—More especially in large towns, all back courts should be provided with an impervious pavement. Earth or causewayed courts are open to organic fouling, especially by children. This fouling on an asphalted court is of less moment, as absorption cannot take place.

Secondly—Such back courts ought to be carefully scavenged daily, or oftener in enteric districts, with a plentiful use of water.

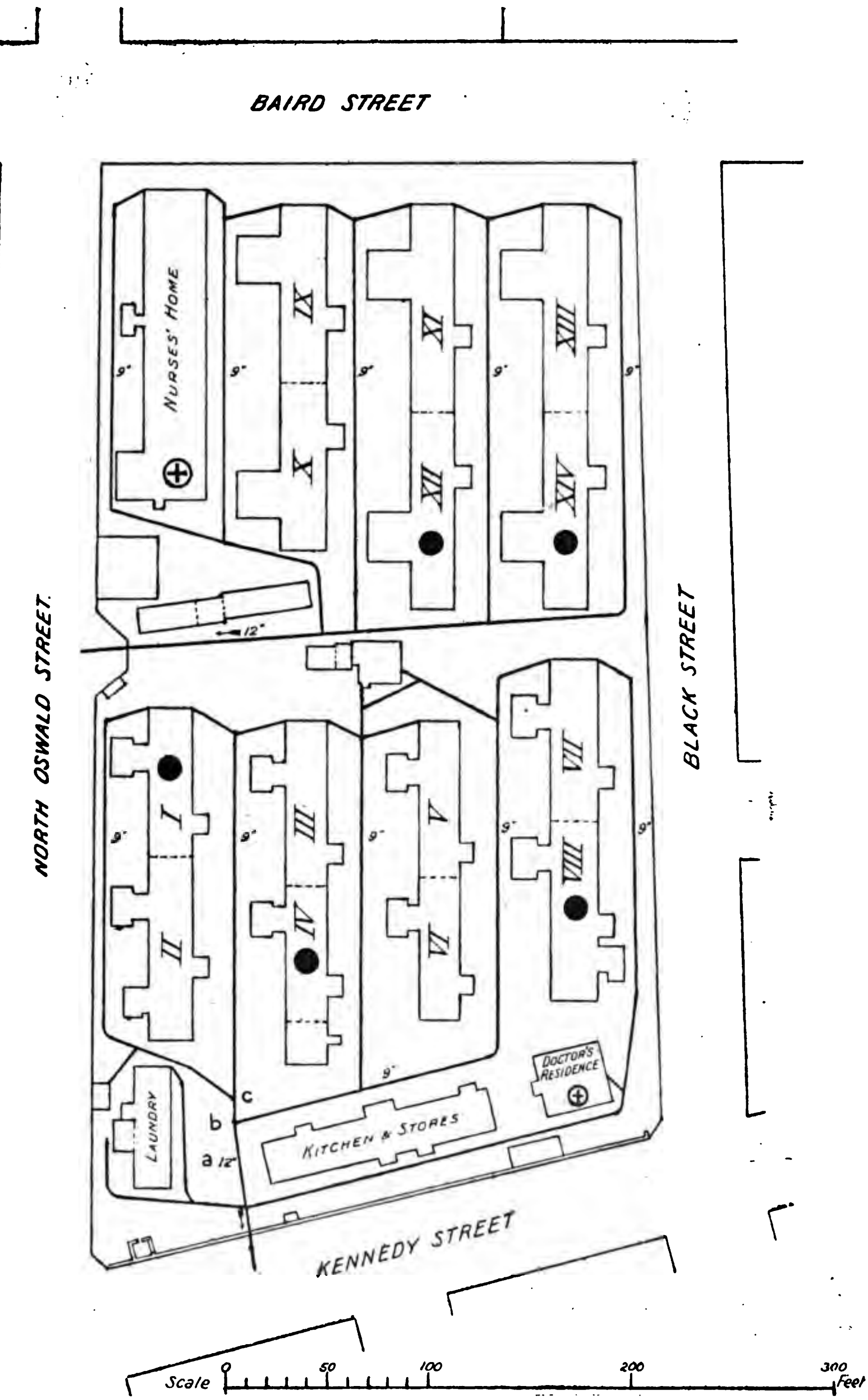
Thirdly—Wet ashpits are extremely objectionable, and should not be tolerated, for not only do they provide a fertile soil for the propagation of the bacillus, but their cleansing may be a new source of the disease, both by aerial contamination, as already indicated, and also by the conveyance of the bacillus to new and possibly as yet unpolluted localities.

Fourthly—From what has already been said, it will be evident that a series of sporadic cases might readily occur in a district without any apparent connection among themselves, yet which,

if our knowledge of the train of associated circumstances were complete, might be traced back to a common source of infection.

Supposing, for example, that the earth from a court contaminated with the enteric poison were turned up during the prevalence of dry weather, it might easily happen that the dust carried about by currents of air and deposited on milk, potted meat, bread, cheese, or other articles of food usually consumed without further cooking, might be the true source of infection. The difficulty would be further increased by the fact that before these sporadic cases could come under observation the actual source of infection would have been long obliterated.

BLOCK PLAN — FEVER HOSPITAL, KENNEDY ST.



DESCRIPTION OF PLATE.

The number of the Wards are marked by Roman numerals.
The thick plain lines show the situation of the drains.
The black circles ● indicate the Wards where undoubted cases of enteric fever occurred.
The crossed circles ⊕ indicate the places where cases of febricula occurred. That in the Nurses' Home was of a nurse who was employed in one of the North Wards, viz., XIII., and who, therefore, was *subject to none of the* more immediate effects of the defective drainage system.

Address presented by the Council of the Philosophical Society and by the Economic Science Section of the Philosophical Society to Andrew Stewart, Glasgow, on 10th June, 1897.

To ANDREW STEWART, Esq., Merchant, Glasgow.

The Philosophical Society of Glasgow, instituted 9th November, 1802, has always taken a deep interest in the teaching of Political Economy as a science essential to the well-being of peoples.

In 1887 this Society created a special department for the furtherance of the study of Economics, and since then this special department, known as the Economic Science Section of the Philosophical Society, has been in active operation.

Until last year it had been a matter of serious regret, and indeed, in a manner, a public reproach, that in the city of Adam Smith no adequate provision had been made for the permanent endowment and efficient teaching of that branch of science with which the name of Adam Smith is so honourably associated, and which is of vital importance in this industrial and commercial community.

In these circumstances you, Sir, came forward, and in the most liberal manner endowed a Chair of Political Economy in the University of Glasgow, named the Adam Smith Chair of Political Economy.

The Philosophical Society of Glasgow desires to place on permanent record its appreciation of this your philanthropic, wise, and patriotic action, which, coming from a fellow-citizen of Adam Smith, has a special grace and propriety.

The Philosophical Society, therefore, asks you to accept this address, with its accompanying casket, that both may be placed among your family records, to be retained, this Society hopes,

during a long continuance of your useful life, and afterwards handed down as an heirloom to your successors.

For the Philosophical Society of Glasgow—

(Signed) EBENEZER DUNCAN,
President.

(„) FREELAND FERGUS,
Honorary Secretary.

For the Economic Section of the Philosophical Society of Glasgow—

(Signed) GEO. HANDASYDE DICK,
President.

(„) ROB. LAMOND,
Honorary Secretary.

MINUTES OF SESSION,

1897-98.

3rd November, 1897.

The Philosophical Society of Glasgow held its First Meeting for Session 1897-98 in the Corporation Galleries of Art, Sauchiehall Street, on the Evening of Wednesday, 3rd November, 1897, at Eight o'clock—Dr. Eben. Duncan, President, in the Chair.

1. The Minutes of Meeting, of date 28th April, 1897, having already been circulated amongst the Members, were held as read, were approved of, and signed by the Chairman.

2. Mr. William W. Carlile and Mr. George Ballantine, Jun., were duly admitted Members of the Society.

3. On the motion of Professor G. G. Henderson, M.A., Mr. A. M. Lindsay and Mr. David Bruce were appointed Auditors to examine the Honorary Treasurer's Accounts for the year 1896-97.

Thereafter the Meeting took the form of a Conversazione. During the evening a number of interesting scientific communications were made, and several pieces of apparatus were shown.

Report of Council for Session 1896-97.

I. *Meetings.*—During the Session 1896-97 fourteen meetings of the Society were held. One of them, which was held on 2nd December, 1896, was devoted to the celebration of the Jubilee of Lord Kelvin as an Ordinary Member, and his election as an Honorary Member. Fifteen communications were made to the Society during the Session.

II. *Science Lectures Association Lecture.*—At the third ordinary meeting of the Session a special lecture was delivered to the Society, being the second lecture under the Glasgow Science Lectures Association Trust. It was delivered by Dr. J. G. M'Kendrick, F.R.S., a former President of the Society, and its subject was "A Study of Sound and Speech Waves as revealed by the Phonograph." There was a large attendance of the public on the occasion.

III. *Visit of Members to the Electric Lighting Station.*—On the 24th April a large party of members visited the Corporation Electric Lighting Station, over which they were shown by the Engineer, Mr. Arnot, and members of his staff.

IV. *Sections.*—The *Architectural Section* held eight meetings in the course of the Session. Mr. P. Macgregor Chalmers, President of the Section, at the opening meeting delivered an address on "Art in our City," which appears in Vol. XXVIII. of the Society's *Proceedings.* No other Section held any separate meetings for the reading of their papers, but contributed them to the Society.

V. *Proceedings, Volume XXVIII.*—This volume of the *Proceedings,* which was distributed to the members of the Society on the 20th August, contains sixteen communications, three of them being from the Architectural Section. One of the papers is in abstract.

VI. *Membership.*—At the beginning of the Session there were 605 Ordinary Members on the Roll. In course of the Session 46 candidates were elected, and 2 Members were reinstated, making 653. Of these, 12 have resigned, and 5 have died, 3 have left Glasgow, and their names have been placed on the "Suspense List," and 6 have been struck off the Roll for non-payment of subscriptions, so that at the beginning of 1897-98 there were 627 Members, being an increase of 22. Of the new Members admitted during the Session, 8 qualified themselves as Life Members. There are now 154 Members of that class out of the 168 who had so enrolled themselves. The Roll now includes 16 Honorary Members (3 being Continental, 4 American or Colonial, and 9 British), 8 Corresponding Members, and 627 Ordinary Members (Annual and Life), or a total of 651.

VII. *Finance.*—The Treasurer's Statement for 1896-97 opens with a balance of £30 5s. 4d., besides the Investment mentioned in former Reports of £294 18s. 3d. The Accounts close with a balance of £71 13s. due to the Treasurer. At Whitsunday a payment of £300 was made in reduction of the Society's half of Bond over the Joint Buildings, and a modification of the rate of interest was thereby obtained. To provide for this, and for current expenditure, it was necessary to realise the greater part of the Investment referred to, which was done at a profit. All current indebtedness to the closing date of financial year is believed to have been paid.

Separate Statements are given by the Treasurer, as formerly, showing the position of the two funds which the Society holds in trust, viz.:— "The Graham Medal and Lecture Fund," and "The Glasgow Science Lecture Fund," respectively.

By Order and in name of the Council,

(Signed) JOHN MAYER,
Acting Secretary.

Report of the Library Committee.

Your Committee have to report that during the past year 107 volumes and 15 parts of works were added to the Library by purchase, and 17 volumes, 39 parts, and 8 pamphlets were presented.

The periodicals received at the Library number 98, of which 67 are bought and 31 are presented. These form altogether 108 volumes a year,

The Society's *Proceedings* were forwarded to 179 Societies and public departments, and 105 volumes and 109 parts were received in return.

Altogether during the year there have been added to the Library 337 volumes, 163 parts of works, and 8 pamphlets, making an estimated total of 12,793 volumes.

Since last report 248 volumes have been bound.

In addition to the large number of works consulted in the Library, 784 books and 734 journals were issued to members during the session.

The following bodies were added, by request, to the list of exchanges :—The Legislative Assembly of Victoria, British Columbia; the Historical and Scientific Association of Duluth, Minnesota; and the Iowa Geological Society.

In Vol. XXVIII. of the *Proceedings* there will be found a list of the additions to the Library by purchase up till June, 1897; the titles of the books presented, with the names of the donors; the names of the Societies, &c., with which exchanges are effected; and a list of the periodicals received at the Library.

JOHN ROBERTSON, Hon. Librarian,
Convener.

17th November, 1897.

The Annual Meeting of the Philosophical Society of Glasgow was held on the Evening of Wednesday, 17th November, 1897, in the Rooms, 207 Bath Street, at Eight o'clock—Dr. Duncan, President, in the Chair.

1. The Minutes of Meeting of 3rd November, 1897, having been printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The Report by the Council on the state of the Society for Session 1896-97, having been printed in the Billet, was held as read, and, on the motion of the Chairman, was adopted.

3. The Honorary Treasurer laid on the table Statements of his Intromissions for the Session 1896-97, signed by Messrs. Lindsay and Bruce, the Auditors appointed at the previous Meeting. On the motion of the Chairman, these Statements were adopted, and Mr. Mann was thanked for his services to the Society as Honorary Treasurer.

4. Mr. John Robertson, the Honorary Librarian, submitted the Report of the Library Committee, which was, on the motion of the Chairman, unanimously adopted.

5. Mr. Gilbert Thomson, who retired by rotation from the office of Vice-President, nominated as his successor Archibald Barr, D.Sc., Professor of Engineering in the University of Glasgow. This was seconded by Dr. G. A. Turner, and unanimously agreed to.

6. On the motion of the Chairman, the Standing Orders were unanimously suspended, and Mr. John Robertson, Mr. John Mann, Freeland Fergus, M.D., and Mr. John Mayer were unanimously re-elected Hon. Librarian, Hon. Treasurer, Hon. Secretary, and Acting Secretary respectively.

7. On the motion of Mr. Scott, seconded by Professor Lodge, Professor Bower, F.R.S.; Professor G. G. Henderson, D.Sc.; Mr. R. F. Muirhead, M.A.; and Mr. A. V. Lothian, M.A., were appointed Members of Council, in room of Dr. Glaister, Professor A. H. Sexton, Mr. A. L. Miller, and Mr. Alexander Scott, who retired by rotation.

8. Dr. Turner then moved, and Mr. Scott seconded, the suspension of the Standing Orders, in order to submit a motion. This was unanimously agreed to.

9. Dr. Turner then moved, and Mr. Scott seconded, the proposal that Article 3 of the Constitution of the Geographical and Ethnological Section read as follows:—"The management of the Section shall devolve upon a Council, consisting of a President, a Vice-President, a Secretary (who shall also act as Treasurer), and six other members." This was unanimously agreed to.

It was also resolved that Dr. George A. Turner be re-elected President; Mr. William Ewing, Vice-President; Dr. James Colville, a Member of Council, each for three years; and that Dr. R. Fullerton be re-elected Secretary and Treasurer.

10. On the motion of Dr. Magnus M'Lean, the Office-Bearers of the Mathematical and Physical Section were re-elected for Session 1897-98.

Dr. ABSTRACT OF HONORARY TREASURER'S

AND COMPARISON WITH

			1896-97.	1895-96.
			£ s. D.	£ s. d.
To BALANCE from last year—				
In Clydesdale Bank, - - - - -		£25 0 0		
Investment, Caledonian Railway, -		294 18 3		
In Treasurer's hands, - - - - -		5 5 4		
			325 3 7	*322 19 8½*
,, SUBSCRIPTIONS to 31st October, 1897—				
46 Entry-moneys of 1896-97 at 21s., - - - - - - - - -		£48 6 0		
Annual Dues at 21s.—				
Arrears, - - - - -	£3 3 0			
For 1896-97, 422 Ordinary Members, - - - -	443 2 0			
,, ,, 38 New Members,	39 18 0			
		486 3 0		
Life Subscriptions at £10 10s.—				
5 Old Members, - - -	£52 10 0			
8 New Members, - - -	84 0 0			
		136 10 0		
			670 19 0	*578 11 0*
,, DIVIDENDS ON INVESTMENT—				
Caledonian Railway, April, 1897, less tax,		£5 4 5		
,, ,, Oct., ,, ,,		5 4 5		
			10 8 10	*11 0 0*
,, CALEDONIAN RAILWAY STOCK—				
Sale of 250 3 per cent. Preferred Converted at 99½,	£248 15 0			
Less Expenses, - - -	1 5 9			
		£247 9 3		
			0 0 0	*0 0 0*
,, GENERAL RECEIPTS—				
Bank Interest, - - - - - - -		£1 3 5		
Proceedings sold, - - - - - -		5 6 11		
			6 10 4	*2 4 2*
,, LEGACY by the late Sir Michael Connal— Third instalment, less duty, - - - - - -			0 0 0	*2 5 0*
,, ARCHITECTURAL SECTION— Associates' fees for 1896-97 at 5s., - - - -			19 15 0	*20 0 0*
,, ECONOMIC SCIENCE SECTION— 14 Associates' fees for 1896-97, at 5s., - - - -			3 10 0	*4 5 0*
,, GEOGRAPHICAL AND ETHNOLOGICAL SECTION— Associates' fees, - - - - - - - - -			0 0 0	*6 15 0*
,, BALANCE due to Treasurer, - - - - - -			71 13 0	*0 0 0*
			1,107 19 9	*947 19 10½*

Memo. by Treasurer.—The Society's Investments are—(1) Bath Street Joint

Buildings, as in last Account, ...		£3,547 8 1½
Half Cost of Electric Light Fittings, 1895-96, ...		31 12 9
Do. Improvements, &c., 1896-97, ...		54 6 6
Sum in Reduction of Bond, as above, ...		300 0 0
		£3,933 7 4½
Less Society's part of £1,700 remaining on Bond, ...		1,200 0 0
		£2,733 7 4½
(2) Caledonian Railway Stock, as in last Account,	£294 18 3	
Less sold, 1896-97, ...	247 9 3	
		47 9 0
	J. M.	£2,780 16 4½

ACCOUNT—SESSION 1896-97. **Cr.**

SESSION 1895-96.

				1896-97.			1895-96.		
				£	s.	d.	*£*	*s.*	*d.*
By GENERAL EXPENDITURE to 31st October, 1897—									
Salary to Secretary, - - - - - -	£75	0	0						
Allowance for Treasurer's Clerks, - -	15	0	0						
Commission to Collector, - - - - -	5	10	0						
				95	10	0	*95*	*15*	*6*
New Books & Periodicals, British & Foreign,	£128	15	0						
Bookbinding, - - - - - - - -	17	12	1						
Printing Circulars, *Proceedings*, &c., -	219	0	0						
Lithographs, &c., for *Proceedings*, &c., -	20	18	6						
Postage and delivery of Circulars, Letters, &c.,	26	3	10						
Stationery, &c., - - - - - - -	4	1	9						
				416	11	2	*302*	*8*	*5*
Fire Insurance on Library for £5,400, -	£6	3	6						
Postages, &c., per Honorary Secretary, £1 1s. 11d.; per Acting Secretary, £1 5s. 6d.; per Treasurer, £2 2s. 7d.; and Sundries, £3 14s. 4d., - - -	8	4	4						
				14	7	10	*12*	*2*	*8½*
,, Joint Expenses of Rooms—Society's half of (1st) £358 2s. 9d., being Interest on Bond, Insurance, Taxes, Cleaning, Repairs, Lighting, and Heating; Salaries of Curator and Assistant; (2nd) of Structural Improvements and New Furnishings, £108 13s., less half of £57 12s. 6d., Revenue from Letting, - -				204	11	7½	*190*	*16*	*3*
,, LORD KELVIN'S JUBILEE MEETING—Expenses, - -				10	7	5½	*0*	*0*	*0*
,, LECTURE EXPENSES—Sundries, - - - - - -				2	9	0	*1*	*5*	*0*
,, SUBSCRIPTIONS TO SOCIETIES—									
Ray Society, 1896, - - - - - -	£1	1	0						
Palæontographical Society, 1896, - -	1	1	0						
				2	2	0	*2*	*2*	*0*
,, SANITARY AND SOCIAL ECONOMY SECTION— Expenses per Treasurer of Section, - - - -				0	0	0	*0*	*2*	*6*
,, ARCHITECTURAL SECTION— Expenses per Treasurer of Section, - - - -				10	13	7	*16*	*11*	*9*
,, ECONOMIC SCIENCE SECTION— Expenses per Treasurer and Secretary of Section, -				3	18	1	*1*	*2*	*8*
,, GEOGRAPHICAL AND ETHNOLOGICAL SECTION— Expenses per Treasurer of Section, - - - -				0	0	0	*0*	*9*	*6*
,, REDUCTION of Society's half of Bond over Buildings, -				300	0	0	*0*	*0*	*0*
,, BALANCE OF—									
Investment—Caledonian Railway £360 3 per cent. Preferred Converted, -	£294	18	3						
Less £250 sold, *per contra*, -	247	9	3						
				47	9	0	*325*	*3*	*7*
				1,107	19	9	*947*	*19*	*10½*

GLASGOW, *10th November, 1897.*—We, the Auditors appointed by the Society to examine the Treasurer's Accounts for the year 1896-97, have examined the same, of which the above is an Abstract, and have found them correct, the Balance due to Treasurer being Seventy-one Pounds Thirteen Shillings Sterling.

(Signed) A M. LINDSAY.
DAVID BRUCE.

JNO. MANN, C.A., *Honorary Treasurer.*

GRAHAM MEDAL AND LECTURE FUND.

Dr. ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1896-97. Cr.

Dr.			Cr.		
CAPITAL AT 1ST NOVEMBER, 1896—			CAPITAL AT 31ST OCTOBER, 1897—		
Glasgow and South-Western Railway Co. 4 °/o Preference Stock in name of the Philosophical Society, in Trust,	£250 0 0		Investment, *per contra*,	£250 0 0	
Value of Die at H.M. Mint,	18 18 0		Die,	18 18 0	
		£268 18 0			£268 18 0
Cash in Bank,		43 18 10	BALANCE, BEING REVENUE—		
REVENUE—			In Bank, on Deposit Receipt,		54 5 1
Dividend, April, 1897, less Tax,	£4 16 8				
„ Oct., „ „	4 16 8				
Interest from Bank,	0 12 11				
		10 6 3			
		£323 3 1			£323 3 1

GLASGOW, 10th November, 1897.—Examined and found correct.

(Signed) A. M. LINDSAY.
DAVID BRUCE.

JNO. MANN, C.A., *Honorary Treasurer.*

THE SCIENCE LECTURES ASSOCIATION FUND.

ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1896-97.

Dr.

CAPITAL AT 1ST NOVEMBER, 1896—		
£200 Caledonian Railway Company 4% Preference Stock, No. 1, in name of the Philosophical Society, in Trust, cost,	£244 4 8	
On Deposit Receipt,	8 5 4	
		£252 10 0
Cash in Bank (Revenue),		42 13 5
REVENUE—		
Dividend, April, 1897, less Tax,	£3 17 4	
,, Oct., ,, ,,	3 17 4	
Interest from Bank,	0 12 8	
		8 7 4
TICKETS sold for Lecture,		3 13 9
		£307 4 6

Cr.

CAPITAL AT 31ST OCTOBER, 1897—		
Investment, *per contra*,	£244 4 8	
In Bank, on Deposit Receipt,	8 5 4	
		£252 10 0
EXPENDITURE—		
Honorarium and Expenses for Lecture on 16th December, 1896, on "A Study of Sound and Speech Waves, as revealed by the Phonograph," by Professor M'Kendrick,		19 0 3
BALANCE, BEING REVENUE—		
In Bank, on Deposit Receipt,		35 14 3
		£307 4 6

GLASGOW, 10th November, 1897.—Examined and found correct.

(Signed) A. M. LINDSAY.
DAVID BRUCE.

JNO. MANN, C.A., *Honorary Treasurer*.

11. On the motion of Mr. G. Handasyde Dick, seconded by Mr. Robert Lamond, the following Office-Bearers were appointed for the Economic Science Section :—

ECONOMIC SCIENCE SECTION.

COUNCIL OF SECTION, 1897-98.

MR. G. HANDASYDE DICK, *President.*

MR. GEORGE YOUNGER,
*MR. W. W. BLACKIE, B.Sc., } *Vice-Presidents.*

Members of Council.

*COUNCILLOR D. M. STEVENSON.	MR. T. N. WHITELAW.
*MR. JAMES F. MARTIN.	MR. ALEX. MACINDOE, C.A.
PROFESSOR WM. SMART, LL.D.	†MR. A. A. MITCHELL, LL.B.

†MR. JOHN A. TODD, B.L.

MR. ROBERT LAMOND, M.A., LL.B., *Hon Secretary.*

MR. JOHN MANN, jun., M.A., C.A., *Hon. Treasurer.*

12. On the motion of Mr. Hector Rey, it was unanimously agreed to elect the following gentlemen as the Council of the Philological Section for the year 1897-98 :—

PHILOLOGICAL SECTION.

JAS. COLVILLE, M.A., D.Sc., *President.*

MR. HECTOR REY, B.A., *Secretary and Treasurer.*

Members of Council.

DR. ROSS.	MR. JUSTUS WIDMER.
DR. ANNANDALE.	MR. DAVID LAMB.
DR. W. BATHGATE, H.M.I.S.	MR. JOHN CLARK, M.A.

13. In the absence of any responsible representative of the Sanitary and Social Economy Section, Dr. Fergus moved the election of the following Office-Bearers, and the motion was unanimously agreed to :—

SANITARY AND SOCIAL ECONOMY SECTION.

PROF. JOHN GLAISTER, M.D., F.F.P.S.G., D.P.H. (Camb.), *President.*

SIR CHARLES CAMERON, BART., M.D., LL.D.,
MR. GILBERT THOMSON, C.E., } *Vice-Presidents.*

(*) *Retires 1898.* (†) *Elected November, 1897, for 3 years.*

Members of Council.

DR. EBEN. DUNCAN.	PROFESSOR JAMIESON, C.E.
DR. A. R. CHALMERS.	MR. WM. KEY.
MR. ALEXANDER SCOTT.	MR. D. M. ALEXANDER.
MR. T. L. WATSON.	MR. D. W. BUCHAN.
MR. WM. RATTRAY.	DR. JAMES K. KELLY.

MR. JOHN ROSS.

MR. WM. KEY, *Honorary Secretary.*

14. The President then called on Dr. Smart, "Adam Smith" Professor of Political Economy in the University of Glasgow, to read his Paper on "The Report of the Royal Commission on Agricultural Depression: What it says, and what it does not say." In an interesting discussion which followed, Messrs. Dick, Lodge, Hedger Wallace, Wright, Carlile, and Maclaurin took part. On the motion of the Chairman, a very cordial vote of thanks was passed to Professor Smart, who briefly replied.

15. The Chairman intimated that the following gentlemen had been elected members of the Society:—

1. Mr. THOMAS FRENCH, 1 Kelvinside Terrace. Recommended by Prof. Archibald Barr, Mr. John F. Campbell, and Mr. J. M'Kellar.

2. Mr. WILLIAM WHITELAW, Hope Cottage, Crookston. Recommended by Mr. John F. Campbell, Mr. J. M'Kellar, and Mr. John Mann.

3. Mr. JOHN SANDEMAN, Rosin Distiller, 35 Kelvinside Gardens. Recommended by Mr. John F. Campbell, Mr. J. M'Kellar, and Mr. John Mann.

4. Mr. WILLIAM GRAY, Shipowner, 65 Great Clyde Street. Recommended by Mr. Archd. Campbell, Mr. D. M. Stevenson, and Mr. Leonard Gow, Jun.

5. Mr. LUDOVIC MACLELLAN MANN, Accountant, 137 West George Street. Recommended by Dr. Eben. Duncan, Dr. Freeland Fergus, and Mr. John Mann.

6. Mr. JOSEPH M'DONALD, Brewer, Wellpark Brewery. Recommended by Mr. Jas. R. Motion, Mr. John Mann, and Mr. Mayer.

7. Mr. R. HEDGER WALLACE, 7 Great Kelvin Terrace. Recommended by Mr. Robert Lamond, Dr. James Colville, and Dr. Oswald Fergus.

8. Mr. DAVID BLYTH ANDERSON, Manufacturer, 18 Park Circus. Recommended by Dr. Freeland Fergus, Dr. Oswald Fergus, and Mr. W. W. Blackie, B.Sc.

9. Mr. JOHN CLARK, M.A., English Master, High School, 2 Kersland Street, Hillhead. Recommended by Dr. James Colville, Mr. Hector Rey, and Prof. A. H. Sexton.

10. Mr. JAMES E. HANBRIDGE, Artist, 8 Balmoral Crescent, Crosshill. Recommended by Mr. William Lang, Mr. John Mann, and Mr. John Mann, Jun.

11. Dr. Jas. H. Nicoll, M.B., Surgeon, 14 Somerset Place. Recommended by Dr. Freeland Fergus, Dr. Eben. Duncan, and Prof. Archibald Barr.

12. Prof. Ralph Stockman, M.D., F.R.S.E., The University, Glasgow. Recommended by Dr. Eben. Duncan, Dr. Freeland Fergus, and Dr. Oswald Fergus.

13. Mr. John M. Welsh, Teacher, 1 Battlefield Crescent, Langside. Recommended by Dr. Eben. Duncan, Mr. W. H. Addison, and Dr. Freeland Fergus.

14. Mr. George Neilson, 34 Granby Terrace, Glasgow. Recommended by Mr. P. Macgregor Chalmers, Mr. John Mann, and Mr. F. T. Barrett.

15. Mr. John Lindsay, City Chambers, Glasgow. Recommended by Mr. Gilbert Thomson, Mr. James D. Borthwick, and Bailie Maclay.

16. Mr. John White, Grain Miller, Scotstoun Mills, Partick. Recommended by Mr. Walter M. Galbraith, Dr. Freeland Fergus, and Mr. Mayer.

17. Dr. William Watson, Gartmore, Langside. Recommended by Dr. Eben. Duncan, Dr. Freeland Fergus, and Dr. Oswald Fergus.

1st December, 1897.

The Second Ordinary Meeting of the Philosophical Society of Glasgow was held at 207 Bath Street, on the Evening of Wednesday, 1st December, 1897, at Eight o'clock—Dr. Duncan, President, in the Chair.

1. The Minutes of Meeting, of date 17th November, 1897, having been printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following new Members were duly admitted :—

1. Mr. Thomas French.
2. Mr. William Whitelaw.
3. Mr. John Sandeman.
4. Mr. William Gray.
5. Mr. Ludovic MacLellan Mann.
6. Mr. Joseph M'Donald.
7. Mr. R. Hedger Wallace.
8. Mr. David Blyth Anderson.
9. Mr. John Clark, M.A.
10. Mr. James E. Hanbidge.
11. Dr. Jas. H. Nicoll.
12. Prof. Ralph Stockman, M.D.
13. Mr. John M. Welsh.
14. Mr. George Neilson.
15. Mr. John Lindsay.
16. Mr. John Whyte.
17. Dr. Wm. Watson.

3. Mr. J. Clark, M.A., English Master, High School of Glasgow, read a paper on "Life and Thought of Anglo-Saxon England as preserved in Contemporary Poetry"—a communication from the Philological Section. In the discussion which followed, the

President, Dr. Colville, and Mr. George Neilson took part. On the motion of the President, Mr. Clark was awarded the thanks of the Society.

4. The President announced that the following gentlemen had been elected Members of the Society :—

1. Mr. GEORGE CHRISTISON, 68 Cambridge Drive. Recommended by Mr. John F. Campbell, Mr. William Henry Houston, and Mr. J. W. D. Walker.
2. Mr. JOHN AITON TODD, B.L., Writer, 133 Greenhead Terrace, Glasgow. Recommended by Dr. William Smart, Mr. George Handasyde Dick, and Mr. Robert Lamond.
3. Mr. JAMES FERGUSON, Electrical Engineer, 16 Dixon Avenue, Queen's Park. Recommended by Dr. Magnus Maclean, Mr. David Reid, and Mr. James Kean.
4. Mr. JAMES FULTON, The Glen, Paisley. Recommended by Mr. Matthew Blair, Dr. Archibald Barr, and Dr. William Smart.
5. Mr. J. H. STEVEN, Ironfounder, Westmount, Kelvinside. Recommended by Mr. Hugh Steven, Mr. John Mann, and Mr. John Mann, Jun.
6. Mr. ALEXANDER KAY STEVEN, Ironfounder, Westmount, Kelvinside, Glasgow. Recommended by Mr. Hugh Steven, Mr. John Mann, and Mr. John Mann, Jun.
7. Mr. ROBERT MARTIN, Engineer, 2 Provan Place, Montrose Street, Glasgow. Recommended by Mr. John G. Kerr, Dr. John Glaister, and Dr. Freeland Fergus.
8. Mr. ROBERT NISH, Merchant, 9 Claremont Terrace. Recommended by Mr. John Farquhar, Mr. John Mann, and Mr. John Mann, Jun.

3rd December, 1897.

On the Evening of 3rd December, 1897, a Special Meeting of the Society was held in the Rooms, 207 Bath Street, at Eight p.m. —Dr. Duncan, President, in the Chair.

The Rev. R. COILLARD delivered a lecture on "The Zambesi from Victoria Falls to Lealuye—the Barotsi Capital, now part of Rhodesia." This lecture was a contribution from the Geographical and Ethnological Section, and was illustrated with a series of lantern slides. During the evening Mr. Ewing, Vice-President of the Section, exhibited a collection of horns and other trophies from Nyassaland. On the motion of the Chairman, both gentlemen were thanked for their communications.

15th December, 1897.

The Third Ordinary Meeting of the Philosophical Society of Glasgow was held at 207 Bath Street, on the Evening of Wednesday, 15th December, 1897, at Eight o'clock—Dr. Duncan, President, in the Chair.

1. The Minutes of Meeting, of date 1st December, 1897, having been printed in the Billet calling the Meeting, were held as read, were approved of, and were signed by the Chairman.

2. The Minutes of a Special Meeting of the Society, held on 3rd December, 1897, were read, were amended, and signed by the Chairman.

3. The following New Members were duly admitted:—

1. Mr. George Christison.
2. Mr. John Aiton Todd, B.L.
3. Mr. James Ferguson.
4. Mr. James Fulton.
5. Mr. J. H. Steven.
6. Mr. Alexander Kay Steven.
7. Mr. Robert Martin.
8. Mr. Robert Nish.

4. The President intimated that Mr. John Mayer had retired from the office of Acting Secretary, and moved that the Society record its hearty thanks to Mr. Mayer for his past services. This was unanimously agreed to.

5. Professor Ferguson, LL.D., F.R.S.E., Honorary Vice-President of the Society, read a paper on "Pierre Borel and his Bibliotheca Chemica." On the motion of the President he received the thanks of the Society.

6. Mr. Carrick Anderson, M.A., B.Sc., Assistant to the Professor of Chemistry, read a paper entitled "A Contribution to the Chemistry of Coal, with special reference to the Coals of the Clyde Basin." Subsequently Professor G. G. Henderson, D.Sc., and Mr. Nathaniel Dunlop made remarks on the paper, and a cordial vote of thanks was awarded to Mr. Anderson.

12th January, 1898.

The Fourth Ordinary Meeting of the Philosophical Society of Glasgow was held at 207 Bath Street, on the Evening of Wednesday, 12th January, 1898, at Eight o'clock—Dr. Duncan, President, in the Chair.

1. The Minutes of Meeting, of date 15th December, 1897, having been printed in the Billet calling the Meeting, were held as read, were approved of, and were signed by the Chairman.

2. Mr. George Handasyde Dick, President of the Economic Science Section, read a paper entitled "Indian Economics," being his Presidential Address for Session 1897-98. A discussion followed, in which Mr. W. Duncan, Mr. W. W. Carlile, Mr. Graham, and Professor Smart took part. On the motion of the President, a hearty vote of thanks was accorded to Mr. Dick.

3. The President announced that the following gentlemen had been unanimously elected Ordinary Members of the Society :—

1. Mr. David Fraser Harris, M.D., B.Sc.(Lond.), F.R.S.E., F.S.A.Scot., Muirhead Demonstrator in the University of Glasgow. Recommended by Prof. M'Kendrick, Dr. Magnus Maclean, and Prof. Ferguson.
2. Mr. Wm. Brodie Brodie, M.B., C.M., Physiological Department, University of Glasgow. Recommended by Prof. M'Kendrick, Dr. Magnus Maclean, and Prof. Ferguson.
3. Mr. T. K. Monro, M.A., M.D., F.F.P.S.G., 10 Clairmont Gardens. Recommended by Mr. A. B. Kirkpatrick, Dr. Pirie, and Dr. F. Fergus.

26th January, 1898.

The Fifth Ordinary Meeting of the Philosophical Society of Glasgow was held at 207 Bath Street, on the Evening of Wednesday, 26th January, 1898, at Eight o'clock—Dr. Turner (in the absence of the President and of the Vice-Presidents) in the Chair.

1. The Minutes of Meeting, of date 12th January, 1898, having been printed in the Billet calling the Meeting, were held as read, were approved of, and were signed by the Chairman.

2. Mr. Grieve Macrone read a paper entitled "Railway Survey Work in the Shiré Highlands, with general observations on the Journey between Chindé and Lake Nyasa," being a contribution from the Geographical Section. A discussion followed, in which the Chairman, Mr. Moir, and Mr. Gibbs took part. On the motion of the Chairman, a hearty vote of thanks was awarded to Mr. Macrone.

3. The following New Members were duly admitted:—

1 Mr. DAVID FRASER HARRIS, M.D., B.Sc.(Lond.), F.R.S.E., F.S.A.Scot.

2. Mr. WM. BRODIE BRODIE, M.B., C.M.

3. Mr. T. K. MONRO, M.A., M.D., F.F.P.S.G.

4. The Chairman announced that the following gentlemen had been unanimously elected Ordinary Members of the Society:—

1. Mr. A. LEWIS M'MILLAN, M.B., C.M., 1 Rosebery Terrace, Great Western Road. Recommended by Mr. William Wallace, Dr. Freeland Fergus, and Mr. Oswald Fergus.

2. Mr. MURE ROBERTSON, M.E., 4 Clairmont Gardens. Recommended by Dr. Freeland Fergus, Mr. Oswald Fergus, and Mr. Wm. Robertson, C.E.

3. Mr. ALEXANDER FYFE (at Clydesdale Bank, 134 West George Street), 52 Grant Street. Recommended by Mr. Geo. Neilson, Mr. F. T. Barrett, and Mr. P. Macgregor Chalmers.

4. Mr. WILLIAM PARNIE, 32 Lynedoch Street, Glasgow. Recommended by Mr. John Dansken, F.S.I., Mr. James Barr, C.E., and Mr. Thos. Adam, F.S.I.

9th February, 1898.

The Sixth Ordinary Meeting of the Philosophical Society of Glasgow was held at 207 Bath Street, on the Evening of Wednesday, 9th February, 1898, at Eight o'clock—Dr. Duncan, President, in the Chair.

1. The Minutes of Meeting, of date 26th January, 1898, having been printed in the Billet calling the Meeting, were held as read, were approved of, and were signed by the Chairman.

2. The following New Members were duly admitted:—

1. Mr. A. LEWIS M'MILLAN, M.B., C.M.
2. Mr. MURE ROBERTSON, M.E.
3. Mr. ALEXANDER FYFE.
4. Mr. WILLIAM PARNIE.

3. (1) Dr. Samuel Sloan explained the construction and mode of action of a "Faradimeter" designed by himself. On the motion of the President, he was accorded a hearty vote of thanks for his Communication. (2) Professor Barr, D.Sc., read a paper entitled "Some Scientific Questions concerning Pictures." A discussion followed, in which Messrs. Falconer, Hunt, Sayers,

Hanbidge, and others, took part. On the motion of the President, a hearty vote of thanks was accorded to Dr. Barr for his paper.

4. The President announced that the following gentlemen had been unanimously elected Ordinary Members of the Society:—

1. Mr. Wm. James Mitchell, M.A., B.L., 49 West George Street. Recommended by Dr. Freeland Fergus, Mr. George Handasyde Dick, and Mr. David Bruce.

2. Mr. James Rowan, Engineer, 22 Woodside Place. Recommended by Dr. Freeland Fergus, Mr. E. H. Parker, and Mr. Oswald Fergus.

3. Mr. Thomas Mason Motion, Works Manager, The Distillers' Company, Limited, Port-Dundas. Recommended by Mr. J. R. Motion, Mr. John Mann, and Mr. W. H. E. Wood.

23rd February, 1898.

The Seventh Ordinary Meeting of the Philosophical Society of Glasgow was held at 207 Bath Street, on the Evening of Wednesday, 23rd February, 1898, at Eight o'clock. Mr. F. T. Barrett, Senior Vice-President, in the absence of the President, occupied the Chair.

1. The Minutes of Meeting, of date 9th February, 1898, having been printed in the Billet calling the Meeting, were held as read, were approved of, and were signed by the Chairman.

2. The following New Members were duly admitted:—

1. Mr. William James Mitchell, M.A., B.L.
2. Mr. James Rowan.
3. Mr. Thomas Mason Motion.

3. Dr. Magnus Maclean read a paper entitled "Lord Kelvin's Patents," which he illustrated by an exhibition of apparatus and by lantern slides. On the motion of Mr. Sayers, a hearty vote of thanks was accorded to Dr. Maclean for his paper.

4. The Chairman announced that the following gentlemen had been duly elected Ordinary Members of the Society:—

1. Mr. Angus M'Lean, B.Sc., C.E., Technical College, George Street. Recommended by Dr. Freeland Fergus, Mr. John Mann, and Mr. Oswald Fergus.

2. Dr. Barr Pollock, 3 Belgrave Terrace, Hillhead. Recommended by Dr. William Wallace, Mr. Scott, and Dr. Lewis M'Millan.

20th April, 1898.

The Eleventh Ordinary Meeting of the Philosophical Society of Glasgow was held within the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 20th April, 1898, at Eight o'clock. Dr. Duncan, President, occupied the Chair.

1. The Minutes of Meeting, of date 6th April, 1898, having been printed in the Billet calling the Meeting, were held as read, were approved of, and were signed by the Chairman.

2. Mr. W. H. Addison read a paper on "The Present State of Deaf Mute Education," and exhibited a number of models, &c., made by deaf-mute children.

A discussion followed, in which Dr. Duncan and Messrs. Haycock, Muirhead, Oswald Fergus, and Sayers took part.

On the motion of the President, a hearty vote of thanks was awarded to Mr. Addison for his paper.

3. Dr. Alex. Ferguson, of the Pathological Department, Glasgow Western Infirmary, read a paper entitled "A Brief Historical and Descriptive Account of the Bubonic Plague." The paper was illustrated by lantern slides and by microscopic preparations.

A discussion followed, in which Drs. Turner and Duncan took part.

On the motion of the President, a hearty vote of thanks was awarded to Dr. Ferguson for his paper.

OFFICE-BEARERS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SESSION 1897-98.

President.

*EBEN. DUNCAN, M.D., C.M., F.F.P.S.G.

Vice-Presidents.

*MR. F. T. BARRETT.
PROFESSOR WILLIAM SMART, LL.D.
PROFESSOR ARCHIBALD BARR, D.Sc.

Honorary Vice-Presidents.

PROFESSOR THE RIGHT HON. LORD KELVIN, G.C.V.O., LL.D., D.C.L., F.R.S., Foreign Associate of the Institute of France, President R.S.E., and Member of the Prussian Order *Pour le Mérite.*
JAMES B. RUSSELL, B.A., LL.D., M.D.
PROFESSOR JOHN GRAY M'KENDRICK, M.D., LL.D., F.R.S., F.R.S.E., F.R.C.P.E.
PROFESSOR JOHN FERGUSON, M.A., LL.D., F.R.S.E., F.C.S., F.S.A., F.S.A.Scot.

MR. JOHN ROBERTSON, *Hon. Librarian.*
MR. JOHN MANN, C.A., *Hon. Treasurer.*
FREELAND FERGUS, M.D., *Hon. Secretary.*

Presidents of Sections.

MR. P. MACGREGOR CHALMERS, I.A., F.S.A.Scot., *Architectural Section.*
JOHN GLAISTER, M.D., F.F.P.S.G., D.P.H.(Camb.), *Sanitary and Social Economy Section.*
GEORGE A. TURNER, M.D., *Geographical and Ethnological Section*
LORD KELVIN, F.R.S., &c., *Mathematical and Physical Section.*
MR. G. HANDASYDE DICK, *Economic Science Section.*
DR. JAMES COLVILLE, M.A., *Philological Section.*

Other Members of Council.

*MR. WM. LANG, F.C.S.
*MR. W. B. SAYERS, M.Inst.E.E.
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*MR. J. CRAIG ANNAN.
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MR. WALTER W. BLACKIE, B.Sc.
MR. P. FALCONER.
MR. JAS. D. BORTHWICK.
PROF. F. O. BOWER, F.R.S.
PROF. G. G. HENDERSON, D.Sc.
MR. R. F. MUIRHEAD, M.A.
MR. A. V. LOTHIAN, M.A.

* *Retire by rotation in November, 1898.*

COMMITTEES APPOINTED BY THE COUNCIL.

COMMITTEE ON FINANCE.

DR. DUNCAN.
MR. WILLIAM LANG.
MR. BORTHWICK.
MR. J. F. CAMPBELL.
MR. JOHN MANN, *Convener.*

COMMITTEE ON THE LIBRARY.

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MR. BARRETT.
PROF. SMART.
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} *Vice-Presidents.*

PROFESSOR FERGUSON.
DR. FERGUS.
PROFESSOR SEXTON.
MR. BLACKIE.
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MR. R. F. MUIRHEAD.
DR. TURNER.
DR. COLVILLE.
MR. CHALMERS.
MR. ANNAN.
MR. LANG.
MR. JOHN ROBERTSON, *Librarian, Convener.*

COMMITTEE ON PAPERS.

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MR. MACGREGOR CHALMERS.
DR. GLAISTER.
DR. TURNER.
LORD KELVIN.
MR. G. HANDASYDE DICK.
DR. COLVILLE.
PROFESSOR SMART.
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PROFESSOR HENDERSON.
MR. PATON.
MR. JOHN ROBERTSON.
MR. JOHN CAMPBELL.
MR. A. V. LOTHIAN.
DR. FERGUS, *Convener.*

"SCIENCE LECTURES" TRUST COMMITTEE.

PROFESSOR M'KENDRICK.
PROFESSOR BOWER.
MR. BARRETT.
DR. FERGUS.
MR. FALCONER.
MR. MAYER.
DR. DUNCAN, *Convener.*

HOUSE COMMITTEE.

Consisting of Members of the Philosophical Society and of the Institution of Engineers and Shipbuilders.

Institution of Engineers and Shipbuilders.

MR. GEORGE RUSSELL.
MR. JAS. GILCHRIST.
PROFESSOR A. JAMIESON.
MR. JAS. MOLLISON.
MR. LINDSAY.

Philosophical Society.

DR. DUNCAN.
DR. FERGUS.
MR. MANN.
MR. ROBERTSON.
MR. LANG.

OFFICE-BEARERS OF SECTIONS, 1897-98.

ARCHITECTURAL SECTION.

President.

MR. P. MACGREGOR CHALMERS, F.S.A.Scot., Architect.

Vice-Presidents.

MR. D. M'BEAN, Architect.
MR. CHARLES CARLTON, Decorator.

Hon. Treasurer.

MR. WILLIAM HOWATT, Measurer, 146 Buchanan Street.

Hon. Secretary.

MR. A. LINDSAY MILLER, 122 Wellington Street.

Honorary Members of Council.

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MR. DAVID THOMSON, Architect.
MR. JAMES THOMSON, Architect.
MR. CAMPBELL DOUGLAS, Architect.
MR. ALEXANDER MUIR, Builder.

Members of Council.

MR. T. L. WATSON, Architect.
MR. JAMES LINDSAY, Architect.
MR. H. D. WALTON, Architect.
MR. H. M'WHANNELL, Architect.
MR. A. BALFOUR, Architect.
MR. R. TURNBULL, Architect.
MR. H. D. HORNE, Decorator.
MR. J. SMELLIE, Measurer.
MR. MALLOCH BAYNE, Glass Merchant.
MR. A. BLACK, Smith.
MR. JOHN L. DUNCAN, Decorator.
MR. R. A. M'GILVRAY, Plasterer.

CHEMICAL SECTION.

(In abeyance.)

BIOLOGICAL SECTION.

(In abeyance.)

SANITARY AND SOCIAL ECONOMY SECTION.

PROF. JOHN GLAISTER, M.D., F.F.P.S.G., D.P.H.(Camb.), *President.*

SIR CHARLES CAMERON, Bart., M.D., LL.D., } *Vice-Presidents.*
MR. GILBERT THOMSON, C.E., }

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DR. A. R. CHALMERS.
MR. ALEXANDER SCOTT.
MR. T. L. WATSON.
MR. WM. RATTRAY.
PROFESSOR JAMIESON, C.E.
MR. D. M. ALEXANDER.
MR. D. W. BUCHAN.
DR. JAMES K. KELLY.
MR. JOHN ROSS.
MR. WM. KEY, *Honorary Secretary.*

GEOGRAPHICAL AND ETHNOLOGICAL SECTION.

GEORGE A. TURNER, M.D., C.M., *President.*

MR. WILLIAM EWING, *Vice-President.*

ROBERT FULLERTON, M.D., *Honorary Secretary and Treasurer.*

Members of Council.

MR. ALEXANDER SCOTT.
MR. ROBERT BLYTH, C.A.
MR. GEORGE MILLER.
MR. ROBERT GOW.
DR. FREELAND FERGUS.
DR. JAMES COLVILLE.

MATHEMATICAL AND PHYSICAL SECTION.

LORD KELVIN, G.C.V.O., D.C.L., F.R.S., *President.*

DR. J. T. BOTTOMLEY, F.R.S., } *Vice-Presidents.*
DR. HENRY DYER, M.A., }

DR. MAGNUS MACLEAN, F.R.S.E., *Honorary Secretary and Treasurer.*

Members of Council.

PROF. JAMES BLYTH, F.R.S.E.
PROF. WILLIAM JACK, LL.D.
PROF. A. JAMIESON, C.E.
MR. A. V. LOTHIAN, M.A.
MR. H. A. MAVOR, M.I.E.E.

ECONOMIC SCIENCE SECTION.

COUNCIL FOR SESSION, 1897-98.

MR. G. HANDASYDE DICK, *President.*

MR. GEORGE YOUNGER, } *Vice-Presidents.*
*MR. W. W. BLACKIE, B.Sc., }

Members of Council.

*COUNCILLOR D. M. STEVENSON.
*MR. JAMES F. MARTIN.
PROFESSOR WM. SMART, LL.D.
MR. T. N. WHITELAW.
MR. ALEX. MACINDOE, C.A.
†MR. A. A. MITCHELL, LL.B.
†MR. JOHN A. TODD, B.L.

†MR. ROBERT LAMOND, M.A., LL.B., *Hon. Secretary.*
MR. JOHN MANN, jun., M.A., C.A., *Hon. Treasurer.*

PHILOLOGICAL SECTION.

JAS. COLVILLE, M.A., D.Sc., *President.*

MR. HECTOR REY, B.A., *Secretary and Treasurer.*

Members of Council.

DR. ROSS.
DR. ANNANDALE.
DR. W. BATHGATE, H.M.I.S.
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MR. DAVID LAMB.
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ADDITIONS TO THE LIBRARY.

Donations, in addition to the Works received in Exchange from the Societies, &c., named on pp. 348-357.

LIST OF BOOKS PRESENTED BY THE RIGHT HON. LORD KELVIN, G.C.V.O.

Lionville. Journal de Mathematiques, Tomes VIII.-XII.
Crelle. Journal der Mathematik, Bände 32-43, in 7 vols.
Montucla. Histoire des Mathematiques, 4 vols.
Lelambre. Astronomie, 3 vols.
Duncan. Solid Geometry.
Do. Plane Geometry.
Frost. Solid Geometry.
Duhamel. Cours d'Analyse.
Arbogast. Calcul des Dérivations.
Carnot. Théorie des Transersales, &c.
Abel. Œuvres.
Cagnoli. Trigonometrie.
Annals of the Cape Observatory, III., VI., VII.
Legendre. Théorie des Nombres.
Landen. Mathematical Memoirs, I.
Waring. Meditationes Analyticae.
Thompson. Electricity and Magnetism.
Price. Infinitesimal Calculus, I., II., IV.
Howard. Art of Reckoning.
Bourquet. Calcul Diff. et Intég., 2 vols.
Hopkins. Trigonometry, and others.
Lacroix. Algèbre.
Do. Calcul des Probabilités.
Do. L'Enseignement, &c.
Leroy. Geométrie.
Larder. Calculus.
Syllabus of Lectures on Trigonometry.
Stewart. Tracts: Physical, &c.
Suzanne. Mathématiques, 3 vols.
Reynaud. Problèmes des Mathématiques.
Potter. Optics, 2 parts.
Townsend. Modern Geometry.
Repeal of the Union Conspiracy.
Young. Selections from "Lays."

Walton. Problems in Hydrostatics.
Cape Meridian Obs., 1861-65.
Alexander. Applied Mechanics.
Langhorne. Reminiscences.
Vincent. Geométrie.
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Hayward. Solid Geometry.
Kerr. Rational Mechanics.
Janett. Algebraic Development.

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Series XV., Himalayan Fossils. Vol. I., Part 4. Permian Fossils of the Productus Shales of Kumaon and Gurhwal. By Carel Diener.

Series XV., Vol. II., Part 1. Cephalopodo of the Lower Trias. By C. Diener.

Series XVI., Fauna of Báluchistan. Vol. I., Part 2. Fauna of the (Necomian) Belemnites Beds. By Fritz Noetling.

Series XVI., Vol I., Part 3. Fauna of the Upper Cretaceous (Maëstrichtien) Beds of the Mari Hills. By Fritz Noetling. From the Survey.

United States Geological Survey—

Atlas to accompany Monograph XXIII. on the Marquette Iron-bearing District of Michigan. By C. R. V. Hise and W. S. Bayley. Washington, 1896. From the Survey.

Batavia Magnetical and Meteorological Observatory—

Wind, Weather, Currents, Tides and Tidal Streams in the Indian Archipelago. By J. P. Van der Stok, 1897. From the Observatory.

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Tables of Remaining Velocity, Time of Flight, and Energy of various Projectiles, 1865-70. By F. Bashforth. 8vo. London, 1871. From the Author.

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Physiological Light. By Raphael Dubois.
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South African Philosophical Society.

Cape of Good Hope Observatory. The Astronomer Royal.

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Royal Geographical Society of Australasia (Queensland Branch

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Royal Society of Victoria, Victoria Street.

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Geological Survey, Department of Mines. The Honourable the Minister for Mines.
Royal Geographical Society of Australasia (New South Wales Branch).
Royal Society of New South Wales, 5 Elizabeth Street, North.
Technological Museum.

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Société Malacologique de Belgique.

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Hamilton Association.

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Geological and Natural History Survey of Canada.
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Library of the Legislative Assembly.

Winnipeg—
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CHINA.

Hong Kong—
Hong Kong Observatory.

ENGLAND AND WALES.

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Midland Institute of Mining, Civil, and Mechanical Engineers, Elden Street.

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Bath Natural History and Antiquarian Field Club.

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Birkenhead Literary and Scientific Society, 34 Hamilton Square.

Birmingham—
Philosophical Society, Medical Institute, Edmund Street.

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Bristol Naturalists' Society. Dr. C. K. Rudge, Ashgrove House, 145 White Ladies' Road, Clifton.

Cambridge—

Philosophical Society, New Museum.
University Library. The Curator.

Cardiff—

Cardiff Naturalists' Society, 44 Loudoun Square.
South Wales, Institute of Engineers, Park Place.

Chelmsford—

Essex Field Club. Hon. Librarian.

Falmouth—

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Folkestone Natural History Society, 98 Dover Road.

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Leeds Philosophical and Literary Society.

Leicester—

Leicester Literary and Philosophical Society.

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Geological Society, Royal Institution, Colquitt Street.
Historic Society of Lancashire and Cheshire, Royal Institution.
Literary and Philosophical Society.
Liverpool Engineering Society, Royal Institution, Colquitt Street.
Liverpool Naturalists' Field Club, Royal Institution, Colquitt Street.

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Anthropological Institute, 3 Hanover Square.
British Association for the Advancement of Science, Burlington House.
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Chemical Society, Burlington House.
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Institution of Junior Engineers, 47 Fentiman Road, Clapham Road.
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Middlesex Hospital, Berners Street.
Patent Office Library, 25 Southampton Buildings, Chancery Lane.
Pharmaceutical Society, 17 Bloomsbury Square.
Royal Geographical Society, 1 Saville Row.
Royal Institute of British Architects, 9 Conduit Street, Hanover Square.
Royal Institution of Great Britain, Albermarle Street, Piccadilly, W.
Royal Meteorological Society, 22 Great George Street, Westminster.

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Royal Photographic Society, 5A Pall Mall, East.

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Society of Biblical Archæology, 37 Great Russell Street, Bloomsbury.

Society of Chemical Industry, Palace Chambers, 9 Bridge Street, Westminster.

Society of Engineers, 17 Victoria Street, Westminster.

Society of Psychical Research, 19 Buckingham Street.

The *Lancet*. The Proprietor, 1 Bedford Street, Strand.

Engineering. The Publisher, 35 Bedford Street, Strand.

Industries and Iron, 39 and 40 Shoe Lane.

Manchester—

Manchester Association of Engineers, Grand Hotel, Aytoun Street.

Geographical Society, 16 St. Mary's Parsonage.

Literary and Philosophical Society of Manchester, 36 George Street.

Middlesborough—

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Société des Sciences Physiques et Naturelles.

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Paris—

École Polytechnique. The Director.

Observatoire Météorologique Central de Montsouris.

GERMANY.

Berlin—

Deutsche Chemische Gesellschaft.

Deutsche Kolonial Verein.

Königliche Preussische Akademie der Wissenschaften.

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Bremen—
Geographische Gesellschaft.

Giessen (Hesse)—
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Griefswald (Prussia)—
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Verein für Erdkunde.
Kaiserliche Leopoldino—Carolinische Deutsche Akademie der Naturforscher.

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Geographische Gesellschaft.

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Belfast Naturalists' Field Club, Museum, College Square, North.
Natural History and Philosophical Society, Museum, College Square, North.

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Royal Irish Academy, 19 Dawson Street.
Trinity College Library.

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Reale Instituto di Lombardo di Scienze, Lettere, ed Arti.

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Seismological Society of Japan. John Milne, Shide Hill House, Shide, Newport, Isle of Wight.
Imperial University of Tokio.

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Mexico—
Observatorio Astronómico Nacional de Tacubaya.
Sociedad Cientifica "Antonio Alzate."
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Académie Royale des Sciences à Amsterdam.

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Lisbon—
Academia Real das Sciencias.

ROUMANIA.

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RUSSIA.

Kazan—
Imperial Kazan University.

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Royal Society, The Mound, Princes Street.

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Archæological Society, 88 West Regent Street.
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Texas Academy of Science.

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American Academy of Arts and Sciences.
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Philadelphia—
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United States Geological Survey.
United States National Museum (Department of the Interior).
United States Naval Observatory.

LIST OF PERIODICALS.

(Those received in exchange are indicated by an asterisk.)

WEEKLY.

Academy.
Architect.
Athenæum.
British Architect.
British Journal of Photography.
Builder.
Builders' Journal.
Building News.
Chemical News.
Comptes Rendus.
*Dingler's Polytechnisches Journal.
Economist.
Electrical Review.
Electrician.
Engineer.
*Engineering.
English Mechanic.
*Industries and Iron.
*Journal of the Society of Arts.
Journal of Gas Lighting, &c.
*Lancet.
Nature.
Notes and Queries.
*Pharmaceutical Journal.
Publishers' Circular.
Scientific American and Supplement.

FORTNIGHTLY.

Annalen der Chemie (Liebig's).
*Berichte der Deutschen Chemischen Gesellschaft.
Journal für Praktische Chemie (Erdmann's).
Zeitschrift für Angewandte Chemie.

MONTHLY.

*American Chemical Journal.
Analyst.
Annalen der Physik und Chemie.
Annales de Chimie et de Physique.
Annales de l'Institut Pasteur.
Annales des Ponts et des Chaussées.
Beiblätter zu den Annalen der Physik und Chemie.
Bookseller.
Bulletin de la Société Chimique de Paris.
Bulletin de la Société d'Encouragement.
Bulletin de la Société Géologique de France.
Bulletin de la Société Industrielle de Mulhouse.
*Bulletin Mensuel de l'Observatoire de Montsouris.
*Canadian Entomologist.
*Deutsche Kolonialzeitung.
Entomologist.
Entomologists' Monthly Magazine.
*Geographical Journal.
Geological Magazine.
*Johns Hopkins University Circulars.
Journal de Pharmacie et de Chimie.
Journal of Botany.
*Journal of the Chemical Society.
Annales des Sciences Naturelles. Botanique.
Annales des Sciences Naturelles. Zoologie.
Annals and Magazine of Natural History.
Antiquary.
*Journal of the Franklin Institute.
*Journal of the Photographic Society.
*Journal of the Society of Chemical Industry.
London, Edinburgh, and Dublin Philosophical Magazine.
*Monatsbericht der Königlich Preussischen Akademie der Wissenschaften zu Berlin.
Monthly List of Official and Parliamentary Papers.
Petermanns Ergänzungsheft.
Petermanns Mitteilungen.
Polytechnic Bibliothek.
*Proceedings of Royal Society of London.
*Proceedings of the Society of Biblical Archæology.
Revue Universelle des Mines.
*Royal Astronomical Society's Monthly Notices.
Sanitary Journal.
Science Gossip.
*Scottish Geographical Magazine.
Zoologist.

QUARTERLY.

Annales des Mines.
Annals of Botany.
Annals of Scottish Natural History.
*Archives Nèerlandaises des Sciences Exactes et Naturelles.
*Bulletin of the American Geographical Society.
Economic Journal.
Forschritte der Mathematik.
Journal of Anatomy and Physiology.
*Journal of the Anthropological Institute of Great Britain.
*Journal of Manchester Geographical Society.
Journal of the Royal Agricultural Society of England.

Journal of the Royal Microscopical Society.
*Journal of the Royal Statistical Society.
*Journal of the Scottish Meteorological Society.
La Nature.
Mind: a Quarterly Review of Psychology and Philosophy.
Quarterly Journal of Economics.
Quarterly Journal of Geological Society.
Quarterly Journal of Microscopical Science.
*Quarterly Journal of Royal Meteorological Society.
Quarterly Journal of Pure and Applied Mathematics.
Reliquary and Illustrated Archæologist.
*School of Mines Quarterly.
*Sociedad Cientifica "Antonio Alzate."
Zeitschrift für Analytische Chemie.

LIST OF MEMBERS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW,

FOR 1897-98.

HONORARY MEMBERS.

(Limited to Twenty.)

WITH YEAR OF ELECTION.

FOREIGN.

Rudolph Albert von Kölliker, Würtzburg. 1860
Ernst Heinrich Hæckel, Jena. 1880
Georg Quincke, Heidelberg. 1890

AMERICAN AND COLONIAL.

Robert Lewis John Ellery, F.R.A.S., Victoria, Australia. 1874
5 Sir John William Dawson, LL.D., F.R.S., Principal of M'Gill College, Montreal. 1883
Thomas Muir, M.A., LL.D., F.R.S.E., Superintendent General of Education, Cape Colony. 1892
Professor S. P. Langley, LL.D., D.C.L., Secretary of the Smithsonian Institution, Washington, U.S.A. 1895

BRITISH.

Sir Joseph Dalton Hooker, K.C.B., K.C.S.I., M.D., D.C.L., LL.D., F.R.S., The Camp, Sunningdale. 1874
Herbert Spencer, care of Messrs. Williams & Norgate, 14 Henrietta street, Covent Garden, London. 1879
10 Rev. John Kerr, LL.D., F.R.S., Glasgow. 1885
Sir George Gabriel Stokes, Bart., M.A., LL.D., D.C.L., F.R.S., Lensfield cottage, Cambridge. 1887
F. Max Müller, M.A., Professor of Comparative Philology, University of Oxford, Norham gardens, Oxford. 1889
The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., *Sec.*R.S., London, Terling place, Witham, Essex. 1890
The Right Hon. Lord Lister, LL.D., D.C.L., *P.*R.S., 12 Park crescent, Portland place, London, W. 1895
15 Sir Archibald Geikie, LL.D., D.Sc., F.R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom, 10 Chester terrace, Regent's Park, London, N.W. 1895
The Right Hon. Lord Kelvin, G.C.V.O., LL.D., D.C.L., F.R.S., Professor of Natural Philosophy, University of Glasgow. 1896
(*Ordinary Member, 1846 till 1896.*)

CORRESPONDING MEMBERS.

WITH YEAR OF ELECTION.

A. S. Herschel, M.A., D.C.L., F.R.S., F.R.A.S., Hon. Professor of Experimental Physics in the Durham College of Science, Newcastle-on-Tyne; Observatory House, Slough, Bucks. 1874
Thomas E. Thorpe, Ph.D., F.R.S., Professor of Chemistry in Royal College of Science, London. 1874
John Aitken, F.R.S., F.R.S.E., Ardenlea, Falkirk. 1883
Alex. Buchan, M.A., LL.D., F.R.S.E., Secretary to the Scottish Meteorological Society, 122 George street, Edinburgh. 1883
5 James Dewar, M.A., F.R.S., F.R.S.E., M.R.I., Jacksonian Professor of Physics, University of Cambridge, and Professor of Chemistry in the Royal Institution of Great Britain, 1 Scroope terrace, Cambridge. 1883
Stevenson Macadam, Ph.D., F.R.S.E., Lecturer on Chemistry, Surgeons' Hall, Edinburgh. 1883
Joseph W. Swan, M.A., F.R.S., Lauriston, Bromley, Kent. 1883
William Milne, M.A., B.Sc., F.R.S.E., Department of Public Education, Cradock, Cape Colony. 1894

ORDINARY MEMBERS.

WITH YEAR OF ENTRY.

* *Denotes Life Members.*

Adam, Stephen, 199 Bath street. 1896
*Adam, Thomas, F.S.I., 27 Union st. 1892
Adam, William, M.A., 235 Bath st. 1876
Adams, William, Makerstoun, Bearsden. 1891
5 Addison, W. H., Superintendent, Deaf and Dumb Institution. 1895
*Agar, Thomas F., Argentine Consul-General, 7 Royal Bank place. 1896
Aikman, C. M., M.A., D.Sc., F.R.S.E., F.I.C., F.C.S., 128 Wellington street. 1886
Alexander, D. M., Marionville, Queen's drive. 1887
Alexander, G. W., M.A., 129 Bath street. 1893
10 Alston, J. Carfrae, 27 James Watt street. 1887
Anderson, Alexander, 157 Trongate. 1869
Anderson, David Blyth, 18 Park circus. 1897
Anderson, James, 168 George street. 1890
Anderson, John, 22 Ann street. 1884
15 Anderson, J. B. Mackenzie, M.B., 42 Lansdowne crescent. 1895
Anderson, R. T. R., 80 Seedhill rd., Paisley. 1889
Anderson, Robert, 44 Albert drive, Crosshill. 1887
Anderson, Robert, 76 Bath street. 1896
*Anderson, T. M'Call, M.D., Professor of Clinical Medicine in the University of Glasgow, 2 Woodside terrace. 1873
20*Anderson, William, 284 Buchanan street. 1890
Anderson, W. F. G., 47 Union street. 1878
*Annan, J. Craig, 234 Sauchiehall st. 1888
Annandale, Charles, M.A., LL.D., 35 Queen Mary avenue. 1888
Arnot, James Craig, 162 St. Vincent street. 1869
25*Arnot, J. L., 116 West Campbell street. 1890
Atkinson, J. B., 10 Foremount terrace, Partick. 1889

Bain, Andrew, 17 Athole gardens. 1890
Bain, Sir James, F.R.S.E., 3 Park terrace. 1866
Bain, Robert, 132 West Nile street. 1869
30*Baird, J. G. A., M.P., Wellwood, Muirkirk. 1892
Ballantine, George, jun., 100 Union street. 1897
Balloch, Robert, Eamont lodge, Dowanhill. 1843
Balmain, Thos., 1 Kew terrace, Kelvinside. 1881
Barclay, A. J. Gunion, M.A., F.R.S.E., High School. 1893
35 Barclay, A. P., 133 St. Vincent st. 1890
Barclay, George, 6 Colebrooke ter. 1891
Barclay, James, 36 Windsor terrace. 1871
*Barr, Archibald, D.Sc., Professor of Civil Engineering and Mechanics in the University of Glasgow, Royston, Dowanhill. 1890
*Barr, James, C.E., I.M., F.S.I., 221 West George street. 1883
40 Barr, Thos., M.D., F.F.P.S.G., 13 Woodside place, W. 1879
Barrett, Francis Thornton, Mitchel Library, *Vice-President.* 1880

Bathgate, William, M.A., 13 Westbourne gardens. 1887
Bayne, A. Malloch, 13 Kelvin drive, Kelvinside. 1878
Beatson, George T., B.A. (Cantab.), M.D., 7 Woodside crescent. 1881
45 Becker, L., Ph.D., Professor of Astronomy in the University of Glasgow, The Observatory. 1895
Begg, Wm., 636 Springfield road. 1883
Beilby, George T., F.I.C., St. Kitts, Slateford. 1895
*Beith, Gilbert, 15 Belhaven terrace. 1881
*Bell, Henry, 39 Fitzjohn's avenue, Hampstead, London, N.W. 1876
50 Bell, Sir James, Bart., 101 St. Vincent street. 1877
*Bell, James T., Northcote, Dowanhill. 1896
*Bell, John J., Northcote, Dowanhill. 1896
Bennett, Robert J., Alloway park, Ayr. 1883
Bergius, Walter, C.E., 77 Queen street. 1897
55 Biles, J. H., Professor of Naval Architecture and Marine Engineering, University of Glasgow. 1893
Bilsland, William, 28 Park circus. 1888
*Bishop, A. Henderson, Burncroft, Thorntonhall. 1896
Black, D. Campbell, M.D., M.R.C.S.E., 121 Douglas street. 1872
Black, J. Albert, Duneira, Row. 1869
60 Black, Malcolm, M.D., 5 Canning place. 1880
*Blackie, J. Alexander, 17 Stanhope street. 1881
*Blackie, J. Robertson, 17 Stanhope street. 1881
Blackie, W. G., Ph.D., LL.D., F.R.G.S., 1 Belhaven terrace, Kelvinside. 1841
*Blackie, Walter W., B.Sc., 17 Stanhope street. 1886
65 Blair, G. M'Lellan, 2 Lilybank terrace. 1869
Blair, J. M'Lellan, Williamcraig, Linlithgowshire. 1869
Blair, Matthew, 5 Hampton Court terrace. 1887
Blyth, James, M.A., F.R.S.E., Professor of Natural Philosophy, Glasgow and West of Scotland Technical College, 204 George street. 1881
*Blyth, Robert, 1 Montgomerie quadrant. 1885
70*Blythswood, The Rt. Hon. Lord, Renfrew. 1885
*Borland, William, 142 St. Vincent street. 1895
Borthwick, James D., 46 Balshagray avenue, Partick. 1891
Bottomley, James T., M.A., D.Sc., F.R.S., F.R.S.E., F.C.S., Demonstrator in Natural Philosophy, University of Glasgow, 13 University gardens, Hillhead. 1880
Bottomley, Wm., C.E., 15 University gardens. 1880
75 Bower, F. O., D.Sc., M.A., F.R.S., F.L.S., Regius Professor of Botany in the University of Glasgow, 45 Kersland terrace. 1885
Boyd, John, Shettleston Iron-works, near Glasgow. 1873
Brier, Henry, M.I.M.E., 13 Ailsa drive, Langside. 1889
Brodie, John Ewan, M.D., C.M., F.F.P.S.G., 5 Woodside place. 1873
Brodie, Wm. Brodie, M.B., C.M., 28 Hamilton Park terrace. 1897
80 Brown, Alexander, 3 Queen's terrace. 1887
Brown, Alex., The Craigs, Carmunnock. 1896
*Brown, Hugh, 5 St. John's terrace, Hillhead. 1887
Brown, James, 76 St. Vincent st. 1876
*Brown, John, 11 Somerset place. 1881
85 Brown, Richard, 138 W. George street. 1895
Brown, Robert, 19 Jamaica street. 1882
*Brown, Wm. Stevenson, 67 Washington street. 1886
*Brown, William, 165 W. George st. 1892
Browne, Richard, Beechholm, Queen's drive, Crosshill. 1893
90 Browne, Robert, B.Sc., 45 Washington street. 1893
Brownlie, Archibald, Bank of Scotland, Barrhead. 1880
Brownlie, J. Rankin, L.D.S.(Eng.), 220 West George street. 1892
Bruce, David, M.A., LL.B., Writer, 49 West George street. 1897
*Bryce, Robert, 82 Oswald street. 1886
95 Buchan, David W., Fairy Knowe, Cambuslang. 1896
Buchanan, Alex. M., A.M., M.D., Professor of Anatomy, Anderson's College Medical School, 98 St. George's road. 1876
Buchanan, George S., 85 Candleriggs. 1845
*Buchanan, Wm., Enderley, Bearsden. 1886
Burnet, John, F.R.I.B.A., I.A., 167 St. Vincent street. 1850
100 Burnet, John James, A.R.S.A., F.R.I.B.A., 18 University avenue. 1892
Burns, J., M.D., 15 Fitzroy place, Sauchiehall street. 1864

Burton, Thomas John, M.D.(Ed.), Lonsdale, Bearsden. 1896

*Caldwell, George B., Scotia Leather Works, Boden street. 1892
Cameron, Sir Charles, Bart., M.P., M.D., LL.D., Greenock. 1870
105 Cameron, H. C., M.D., 200 Bath st. 1873
*Campbell, Archibald, Springfield quay. 1895
*Campbell, J. A., LL.D., M.P., Stracathro, Brechin. 1848
*Campbell, James, 137 Ingram st. 1885
*Campbell, John Ferguson, 2 Holborn terrace, N., Kelvinside. 1892
110 Campbell, John MacNaught, C.E., F.Z.S., F.R.S.G.S., Kelvingrove Museum. 1883
Campbell, Malcolm, 18 Gordon st. 1894
*Campbell, Thomas, Maryhill Ironworks. 1894
Carlile, William W., Hailie, Largs, Ayrshire. 1897
Carmichael, Neil, M.D., C.M., F. F. P. S. G., Invercarmel, 23 Nithsdale drive, Pollokshields. 1873
115 Carver, Thomas, A.B., B.Sc., C.E., Heigham, Aubrey road, Hornsey, London, N. 1890
Cassells, John, 62 Glencairn drive, Pollokshields. 1890
Cassells, Robert Dunlop, B.Sc., 62 Glencairn drive, Pollokshields. 1895
*Cayzer, Sir Charles W., M.P., 109 Hope street. 1886
Chalmers, A. K., M.D., D.P.H. (Camb.), 23 Kersland terrace. 1892
120 Chalmers, George, 13 Hamilton crescent, Partickhill. 1896
Chalmers, James, I.A., 93 Hope st. 1884
Chalmers, P. MacGregor, I.A., F.S.A.Scot., 95 Bath street. 1891
Cherrie, James M., Clutha cottage, Tollcross. 1876
*Chisholm, Samuel, 4 Royal ter., W. 1890
125*Christie, Henry W., Levenfield house, Alexandria. 1892
Christie, John, Turkey-red Works, Alexandria, Dumbartonshire. 1868
Christison, George, 68 Cambridge drive. 1897
Chrystal, W. J., F.I.C., F.C.S., Shawfield Works, Rutherglen. 1882
Clark, John, Ph.D., F.I.C., F.C.S., 138 Bath street. 1870
130 Clark John, 9 Wilton crescent. 1872
Clark, John, M.A., 2 Kersland st., Hillhead. 1897
*Clark, William, 125 Buchanan st. 1876
*Cleland, John, M.D., LL.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 1884
*Coats, Joseph, M.D., Professor of Pathology in the University of Glasgow, 8 University gardens. 1873
135*Cochran, Robert, 7 Crown circus, Dowanhill. 1877
Coghill, Wm. C., 263 Argyle street. 1873
*Colquhoun, James, LL.D., 158 St. Vincent street. 1876
Colville, James, M.A., D.Sc., 14 Newton place. 1885
Combe, James Russell, 257 West Campbell street. 1895
140 Connell, William, 44 St. Enoch sq. 1870
Connell, William, jun., Coldstream, Cathkin road, Langside. 1897
Cooke, Louis H., A.R.S.M., Royal School of Mines, London. 1893
Copland, Wm. R., M.Inst.C.E., F.S.I., 146 West Regent street. 1876
Core, Wm., M.D., Medical Superintendent, Barnhill Hospital. 1891
145 Coste, Jules, French Consulate, 131 West Regent street. 1888
Costigane, John T., Limekilns house, East Kilbride. 1889
Costigane, William, Clifton hall, Albert drive, Pollokshields. 1890
Coubrough, A. Sykes, Parklea, Blanefield, Strathblane. 1869
Coulson, W. Arthur, 47 King street, Mile-end. 1888
150 Couper, James, Craigforth house, Stirling. 1862
Couper, Sinclair, Moore Park Works, Helen street, Govan. 1896
Cowan, M'Taggart, C.E., 53 Ashton terrace, Hillhead. 1876
Craig, T. A., C.A., 139 St. Vincent street. 1886
Crawford, Wm. C., M.A., Lockharton gardens, Colinton road, Edinburgh. 1869
155 Cree, Thomas S., 21 Exchange sq. 1869
Crichton, James, 201 Nithsdale road, Pollokshields. 1892
Crosbie, L. Talbot, Scotstounhill, Whiteinch. 1890
Cross, Alexander, M.P., 14 Woodlands terrace. 1887
*Crum, Walter G., Thornliebank. 1895
160 Crum, William G., Thornliebank. 1896
*Curphey, Wm. Salvador, Borva, Lenzie. 1883
Cuthbert, Alexander A., 14 Newton terrace. 1885
*Cuthbertson, Sir John N., LL.D., 29 Bath street. 1850
Cuthbertson, Thomas W., M.A., 25 Blythswood square. 1897

165 Dalziel, J. Kennedy, M.B., C.M., 196 Bath street. 1896

295 Jenkins, Thomas Wilson, M.A., M.D., 1 Newark drive. 1892
Johnston, David, 160 West George st. 1891
Johnston, George, Mosesfield, Springburn. 1896
Johnstone, Jas., Coatbridge street, Port-Dundas. 1869

Kay, Wm. E., F.C.S., 47 Camphill street, Crosshill. 1887
300 Kean, James, 32 Scotia street, Garnethill. 1888
Kelly, James K., M.D., F.F.P.S.G., Park villa, Queen Mary avenue, Crosshill. 1889
Kennedy, James, 33 Greendyke street. 1889
Ker, Charles, M.A., C.A., 115 St. Vincent street. 1885
*Ker, Wm., 1 Windsor ter., West. 1874
305 Kerr, Adam, 175 Trongate. 1887
Kerr, Charles James, 44 West George street. 1877
Kerr, Geo. Munro, 97 Buchanan street. 1890
Kerr, John G., M.A., 15 India st. 1878
Key, William, 109 Hope street. 1877
310 King, James, 57 Hamilton drive, Hillhead. 1848
King, Sir James, Bart., LL.D., of Campsie, 115 Wellington street. 1855
King, John, Tigh Ruadh, Possilpark. 1895
King, John Y., 142 St. Vincent street. 1893
Kirk, Robert, M.D., Newton cottage, Partick. 1877
315 Kirkpatrick, Alexander B., 88 St. Vincent street. 1885
Kirkpatrick, Andrew J., 179 West George street. 1869
Kirkwood, James, Carling lodge, Ibrox. 1890
Knight, James, M.A., B.Sc., F.C.S., F.G.S., The Shieling, Uddingston. 1893
*Knox, David J., 19 Renfield street. 1890
320 Knox, John, 41 Mid Wharf, Port-Dundas. 1883

Laird, George H., 3 Seton terrace, Dennistoun. 1882
Laird, John, Marchmont, Port-Glasgow. 1876
Laird, John, Royal Exchange Sale Rooms. 1879
Lamb, David, 3 Albion place, Dowanhill. 1896
325 Lamond, Robert, M.A., LL.B., 163 West George street. 1894
Lang, William, F.C.S., Crosspark, Partick. 1865
*Lauder, James, F.R.S.L., Glasgow Athenæum. 1892
Lauder, John, 87 Union street. 1894
Law, John R. K., 20 Ashton gardens, Dowanhill.
330 Leslie, John A., jun., 48 Cadogan street. 1894
*Lindsay, Archd. M., M.A., 87 West Regent street. 1872
Lindsay, John, City Chambers. 1897
Lodge, Richard, M.A., Professor of History, University of Glasgow. 1895
Lothian, Alex. V., M.A., 11 Holborn terrace. 1893
335 Love, James Kerr, M.D., C.M., 10 Newark drive. 1888
Lundholm, C. O., Nobel's Explosives Factory, Ardeer, Stevenston. 1890

M'Ara, Alexander, 65 Morrison street. 1888
M'Arly, Thomas, 29 West George street. 1897
MacArthur, J. G., Rosemary villa, Bowling. 1874
340*MacArthur, John S., 108A Hope st. 1890
M'Bain, W. C., 75 Jamaica street. 1895
M'Callum, Robert, jun., 69 Union street. 1891
*M'Clelland, Andrew Simpson, C.A., 4 Crown gardens, Dowanhill. 1884
M'Conville, John, M.D., 27 Newton place. 1870
345 M'Cracken, James, 5 Bowmont terrace, Kelvinside. 1889
M'Crae, John, 7 Kirklee gardens, Kelvinside. 1876
M'Creath, James, M.E., 208 St. Vincent street. 1874
M'Culloch, Hugh, 154 West Regent street. 1880
Macdonald, Archibald G., 8 Park circus. 1869
350*M'Donald, David, 11 Huntly gardens, Kelvinside. 1897
*Macdonald, John, 72 Great Clyde street. 1896
M'Donald, Joseph, Wellpark brewery. 1897
Macdonald, Thomas, 50 Gibson street, Hillhead. 1869
*Macfarlane, Walter, 12 Lynedoch crescent. 1885
355 M'Farlane, Wm., Edina lodge, Rutherglen. 1888
*M'Gilvray, R. A., 129 West Regent street. 1880
M'Gregor, Duncan, F.R.G.S., 37 Clyde place. 1867
M'Houl, David, Ph.D., Dalquhurn Works, Renton. 1883

*Macindoe, Alex., C.A., 104 West George street. 1894
360 Mackintosh, Donald J., M.B., C.M., Western Infirmary. 1894
Macintyre, John, M.B., C.M., 179 Bath street. 1895
M'Intyre, Wm., Marion bank, Rutherglen. 1888
M'Kellar, John C., 112 Bath street. 1896
M'Kellar, J., 25 Kelvinside terrace. 1893
365*M'Kendrick, John G., M.D., C.M., LL.D., F.R.S., F.R.S.E., F.R.C.P.E., Professor of Institutes of Medicine in the University of Glasgow, 2 Florentine gardens, *Hon. Vice-President.* 1877
*M'Kenzie, W. D., 43 Howard street. 1875
*M'Kenzie, W. J., 24 Wilton gardens, North, Kelvinside. 1879
Mackinlay, David, 6 Great Western terrace, Hillhead. 1855
*Mackinlay, James Murray, 4 Westbourne gardens. 1886
370 M'Kissack, John, 68 West Regent street. 1881
Maclae, A. Crum, 147 St. Vincent street. 1884
M'Laurin, Robert, 303 Main street, Maryhill. 1895
*Maclay, David T., 169 W. George street. 1879
Maclay, W., Eildon villas, Mount Florida. 1893
375 M'Lean, Angus, B.Sc., C.E., Technical College, George street. 1897
Maclean, Magnus, M.A., F.R.S.E., D.Sc., 8 St. Albans ter., Hillhead. 1885
MacLehose, James J., M.A., 61 St. Vincent street. 1882
*Macleod, A., 3 Dundas street. 1893
M'Lennan, James, 40 St. Andrew's street. 1888
380 M'Millan, A. Lewis, M.B., C.M., 1 Rosebery ter., Gt. Western rd. 1897
Macnair, D. S., Ph.D., B.Sc., Glenogle, Kilmalcolm. 1895
Macouat, R. B., 37 Elliot street. 1885
Macphail, Donald, M.D., Garturk cottage, Whifflet, Coatbridge. 1877
M'Pherson, George L., 30 Albert road, Crosshill, East. 1872
385 M'Vail, D. C., M.B., Professor of Clinical Medicine, St. Mungo's College, 3 St. James' terrace, Hillhead. 1873
Machell, Thomas, 1 Burnbank ter. 1886
Main, Robert B., 56 Dalziel drive. 1885
Malloch, A. M., Firhill, Garscube road. 1896
Mann, John, C.A., 137 West George street, *Treasurer.* 1856
390 Mann, John, jun., M.A., C.A., 137 West George street. 1885
Mann, Ludovic MacLellan, 137 West George street. 1897
Manwell, James, The Hut, 4 Albert drive, Pollokshields. 1876
Marshall, T. Rhymer, D.Sc., Professor of Chemistry in St. Mungo's College, 19 Sandyford place. 1894
Martin, Jas. F., 63 Brunswick street. 1895
395 Martin, Robert, 2 Provan place, Montrose street. 1897
Martin, William, 116 St. Vincent st. 1892
Marwick, Sir J. D., LL.D., F.R.S.E., 19 Woodside terrace. 1878
Mathie, George M., 15 Wardlawhill terrace, Rutherglen. 1895
Mathieson, J. H., 3 Grosvenor ter., Kelvinside. 1896
400 Mathieson, T. O., 3 Grosvenor ter. 1896
Mavor, Henry A., 47 King street, Mile-end. 1887
Mavor, James, The University, Toronto, Canada. 1885
Mavor, Samuel, 37 Burnbank gard. 1890
Mayer, John, Strathview, Cathkin road, Langside. 1860
405 Mechan, Arthur, 60 Elliot street. 1876
Mechan, Henry, 60 Elliot street. 1879
Meikle, Andrew W., M.A., Viewfield house, Pollokshields. 1890
Menzies, Thos., Hutchesons' Grammar School, Crown street. 1859
Menzies, William Crawford, City Improvement Trust, 34 Trongate. 1895
410 Millar, James, 158 Parliamentary rd. 1870
Miller, A. Lindsay, 122 Wellington street. 1878
*Miller, Arch. Russell, Castlebank, Bothwell. 1884
Miller, Major David S., 8 Royal crescent, W. 1887
*Miller, George, Winton drive, Kelvinside. 1881
415 Miller, G. J., Frankfield, Shettleston. 1888
Miller, Richard, 6 Dixon street. 1885
*Miller, Thos. P., Cambuslang Dyeworks. 1864
Mills, Edmund J., D.Sc., F.R.S., "Young" Professor of Technical Chemistry, Glasgow and West of Scotland Technical College, 60 John street. 1875
Mirrlees, James B., Redlands, Kelvinside. 1866
420*Mirrlees, William J., 45 Scotland st. 1889
Mitchell, Andrew, C.A., The Glasgow District Subway Co., Factor and Treasurer's Office, St. Enoch Square Station. 1896

*Mitchell, George A., 5 West Regent street. 1883
Mitchell, Robert, 12 Wilson street, Hillhead. 1870
Mitchell, Wm. James, M.A., B.L., 49 West George street. 1897
425 *Moffatt, Alexander, 23 Abercromby place, Edinburgh. 1874
Mollison, James, 6 Hillside gardens, Partick. 1889
*Mond, Robert Ludwig, B.A. (Cantab), F.R.S.E., 20 Avenue road, Regent's park, London, N.W. 1890
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*Muir, Allan, Ardmay, Newlands road, Langside. 1881
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*Napier, John, Audley mansions, Grosvenor square, London. 1849
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*Neilson, James, 116 Bishop street, Port-Dundas. 1896
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*Pollock, R., M.B., C.M., F.F.P.S.G., Laurieston house, Pollokshields. 1883
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535 Sloane, F. N., C.A., 187 West George street. 1893
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540 Smith, D. Johnstone, C.A., 149 W. George street. 1888
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*Smith, J. Guthrie, 54 W. Nile st. 1875
*Smith, Robert B., Bonnybridge, Stirlingshire. 1884
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*Spencer, Charles L., Edgehill, Kelvinside. 1891
550*Spencer, J. J., Edgehill, Kelvinside. 1895
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*Spiers, John, 493 Great Western road, Hillhead. 1885
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555*Stephen, John, Domira, Partick. 1880
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*Steven, Hugh, Westmount, Montgomerie drive. 1869
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*Stevenson, D. M., 12 Waterloo st. 1889
*Stevenson, Jas., F.R.G.S., 23 West Nile street. 1870
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*Sutherland, John, Great Western Hotel, Oban. 1880
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580 Tatlock, John, F.I.C., 13 Parkgrove terrace, West, Sandyford. 1875
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585 Tennent, Gavin P., M.D., 159 Bath street. 1875
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595 Townsend, C. W., Crawford street, Port-Dundas. 1890
*Tullis, David, St. Ann's Leather Works, Bridgeton. 1894
*Tullis, James Thomson, Anchorage, Burnside, Rutherglen. 1883
*Turnbull, John, jun., M.I.M.E., 18 Blythswood square. 1883
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*Walker, Archibald, M.A. (Oxon.), F.I.C., F.C.S., 8 Crown terrace, Dowanhill. 1885
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*Wallace, Hugh, Bank of Scotland, 544 St. Vincent street. 1879
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610*Wallace, Wm., M.A., M.B., C.M., 25 Newton place. 1888
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Warren, John A., C.E., 115 Wellington street. 1887
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615 Watson, James, 6 Kirklee road, Kelvinside, W. 1873
*Watson, John, 205 West George street. 1886
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*Watson, J. Robertson, M.A., Professor of Chemistry, Anderson's College Medical School, Dumbarton road. 1891
*Watson, Thomas Lennox, I.A., F.R.I.B.A., 166 Bath street. 1876
620*Watson, Sir William Renny, 16 Woodlands terrace. 1870
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625 Westlands, Robert, 4 Dixon street. 1869
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*Whitelaw, Thomas N., 87 Sydney street. 1892
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630*Whitson, Jas., M.D., F.F.P.S.G., 13 Somerset place. 1882
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645 Wood, W. E. H., 40 Candleriggs. 1891
*Wood, Wm. Jas., 38 Cochrane street. 1893
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650 Young, John, 88 Renfield street. 1881
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